QUAIN AND SHARPEY'S

QUAIN'S ANATOMY.

VOL. II.

HUMAN ANATOMY.

BY

JONES QUAIN, M.D.

EDITED BY

RICHARD QUAIN, F.R.S.

AND

WILLIAM SHARPEY, M.D. F.R.S.

PROFESSORS OF ANATOMY AND PHYSIOLOGY, IN UNIVERSITY COLLEGE, LONDON.

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CONTENTS OF THE SECOND VOLUME.

ELEMENTS OF ANATOMY.

VEINS.

The veins are those vessels through which the blood returns from the capillaries to the heart. They admit of being arranged into two distinct classes; viz., the *systemic veins*, which convey the dark or effete blood from all parts of the body back to the right auricle of the heart; and the *pulmonary veins*, by which the reoxygenated or red blood is carried from the lungs to the left auricle of that organ.

The *pulmonary* veins, a distinct set of vessels from the bronchial veins or veins concerned in the nutrition of the lungs, serve a special use connected with respiration, and will be described with the anatomy of the respiratory organs.

The *systemic* veins, which are now to be considered, commence in the capillary vessels of all parts of the body by means of small branches, which, uniting into fewer and larger branches, and anastomosing freely with each other, end for the most part in two large venous trunks—the upper and lower venæ cavæ—which empty their contents into the right auricle of the heart. The veins from the walls of the heart itself open at once into the cavity of the right auricle.

There is, however, one set of systemic veins (those of the chylopoietic viscera,) the large branches of which do not tend directly to the heart or to one of its great veins. Thus, the veins of the stomach, intestines, pancreas, and spleen unite into a single large trunk, which again branches out in the manner of an artery within the liver, and ends in a capillary system in the substance of that gland. This large venous trunk is the *portal vein* (vena portæ); and the branches of which it is composed, with those into which it divides within the liver, constitute the *portal system* of veins.

Other veins, named *hepatic*, commencing in the capillaries of the liver, and resembling in their arrangement the systemic veins generally, convey the blood to the lower vena cava, and thence to the heart.

The veins of many parts of the body consist of a subcutaneous and a deep set, which have very frequent communications one with the other. In some parts of the body, to be mentioned particularly hereafter, the veins are provided with valves, whilst in others no valves exist.

[In some positions the veins are so numerous, and so frequently anastomose, as to form plexuses so close as hardly to leave any appreciable

interval; as around the prostate gland and neck of the bladder, the rectum, interior surface of the spinal canal, &c. The deep veins probably do not present more frequent anomalies of distribution than the arteries, but the superficial ones vary their course more frequently.]

The systemic veins may be arranged and described in certain groups, according to their mode of termination in the heart.

a. In the first group are included the various branches of the *upper vena cava*, viz., those of the head, neck, upper limbs, and walls of the thorax. With this part of the venous system the cerebro-spinal veins may also be arranged; and the azygos veins (great and small) also belong to this upper group of veins, and serve to connect it with the next or lower set.

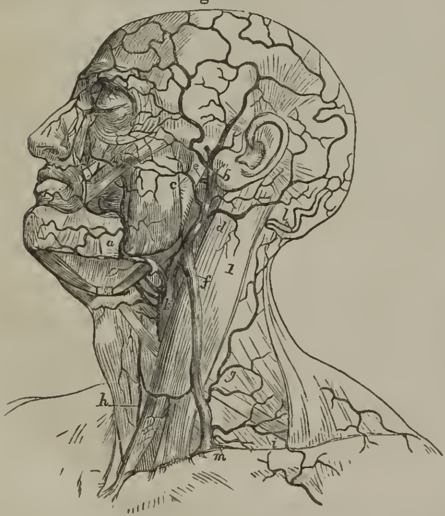
b. The second group of veins consist of those which end in the lower vena cava. They are derived from the lower limbs, and from the lower part of the trunk—the *portal system* being considered as an adjunct.

c. Lastly, the veins from the substance of the heart open directly into the right auricle, and are therefore not connected with either of the sets of veins ending in the two venæ cavæ.

THE VEINS OF THE HEAD, FACE, AND NECK.

The veins of the head are divided, like the arteries, into two sets,—those which ramify on its exterior, and those placed in its interior. The latter, or cerebral veins and sinuses, will be presently described. The veins of the head and neck, with one exception, have no valves. The external jugular vein, the exception alluded to, is provided with a valve at its entrance into the subclavian vein; and in most cases with another about the middle of its course. These valves, however, are not efficient in stopping the regurgitation of the blood, or the passage of injections from below upwards.

Fig. 256.



The veins on the exterior of the head and face converge and unite, so as to form two trunks, the facial and the temporal veins.

FACIAL VEIN.

The *facial* vein, fig. 256, *a*, [vena facialis,] lies obliquely along the side of the face, extending from the inner margin of the orbit downwards and outwards to the anterior border of the masseter muscle. Resting on the same plane as the facial artery, but farther back, and less tortuous, it still has very nearly the same connexions with other parts. It may be said

to commence at the side of the root of the nose by a vein formed by the junction of branches from the forehead, eyebrow, and nose, and to increase by receiving others during its course.

The *frontal* vein, [v. frontalis,] commences on the roof of the skull by branches, which descend obliquely inwards upon the forehead, maintaining communications in their course with the anterior branches of the temporal vein. By gradually converging, these branches form a vein of some size, which descends vertically, parallel with the corresponding vessel of the opposite side, with which it is connected by transverse branches. In some instances the veins of the two sides unite and form a short trunk, which again divides into two branches at the root of the nose. These branches diverge as they run along the sides of the nose at its root, where each becomes continuous with the corresponding angular vein. As it descends from the forehead, the frontal vein receives a branch from the eyebrow, and some, of smaller size, from the nose and upper eyelid.

The *supra-orbital* vein (*v. supercilii*) runs inwards in the direction of the eyebrow, covered by the occipito-frontal muscle. Its branches are connected externally with those of the external palpebral and superficial temporal veins; in its course it receives branches from the contiguous muscles and integument, and at the inner angle of the orbit inclines downwards, to terminate in the frontal vein.

The supra-orbital and frontal veins, by their junction, form the *angular vein*, which is perceptible beneath the skin as it runs obliquely downwards and outwards by the inner margin of the orbit, resting against the side of the nose at its root. This vessel receives by its inner side the *nasal veins*, which pass upwards obliquely to join it from the side and ridge of the nose; whilst some small palpebral veins open into it from the opposite direction. Opposite the lower margin of the orbit, the angular vein may be said to terminate by becoming continuous with the facial vein.

The *facial vein*, commencing as has been just stated, gradually increases, as it receives branches from the lower eyelid, from the ala of the nose, and from the upper lip. By its outer side it receives two or three veins (*inferior palpebral*), which are formed by small branches derived from the lower eyelid, from the outer side of the orbit, and from the cheek. The direction of these palpebral branches is obliquely inwards above the zygomatic muscle, beneath which they turn previously to their termination. On a level with the angle of the mouth, the facial vein receives *communicating* branches (deep facial) from the pterygoid plexus, and also some branches proceeding from the orbit, furnished by the infra-orbital and other branches of the internal maxillary vein. In front, the facial vein is further increased by branches from the lips (labial), and behind by others from the cheek (buccal); still lower down, by branches from the masseter muscle (masseteric) on the one hand, and from the chin on the other. Having reached the base of the lower maxilla, the vein inclines outwards and backwards, covered by the cervical fascia and the platysma muscle; and soon unites with a large branch of communication derived from the temporal vein, to form a vessel of considerable size, which joins obliquely the trunk of the internal jugular vein, *k*.

Previously to its termination, the facial vein receives the following branches: The *ranine* vein, a small vessel which lies along the under surface of the tongue, close by the frænum linguæ, in apposition with the artery of the same name; its course is backwards and outwards, between the mylo-hyoid and hyo-glossus muscles, to open into the facial vein, or sometimes into the lingual. The *submental* vein, larger than the preceding, commences in the sublingual gland, from which it passes backwards in the course of the duct; it receives branches from the submaxillary gland, and from the mylo-hyoid muscle, and, keeping close under cover of the margin of the jaw-bone, joins the facial vein; but in some instances enters the lingual or superior thyroid vein. The *palatine* vein returns the blood from the plexus around the tonsil and from the soft palate; it passes downwards, deeply seated by the side of the pharynx, to join one of the preceding veins, or terminate in the facial separately.

TEMPORAL VEIN.

The *temporal* vein, fig. 256, *b*, (*vena temporalis*,) a vessel of considerable size, descends in front of the external auditory tube, reaching from the zygoma, upon which it rests, to the angle of the jaw, and resulting from the union of branches which are spread out upon the side of the head, some being superficial, and others deeply seated. The superficial branches commence upon the arch of the skull, where they communicate with the ramifications of the frontal and occipital veins, as well as with those of the corresponding vein of the opposite side. Those from the fore part incline downwards, and a little backwards, whilst the posterior branches run forwards over the ear; all being placed between the skin and the temporal fascia. Converging in this way, they unite at an angle above the zygoma, and at their junction commences the trunk of the temporal vein. To the same point also passes a large branch, which may be called the *middle temporal* vein, to distinguish it from those which are still deeper seated and open into the internal maxillary vein. This vessel arises in the substance of the temporal muscle, from which the branches emerge, to form a vessel of some size upon its surface; this vessel pierces the fascia at the upper border of the zygoma, and opens into the upper part of the common temporal trunk just alluded to. The temporal vein gradually sinks into the substance of the parotid gland as it descends behind the ramus of the jaw. Beneath the angle of that bone, it divides into two vessels, of which one, ordinarily the larger, inclines inwards to join with the facial vein, whilst the other turns backwards, and becomes continuous with the external jugular vein, *f*. The branches which open into the temporal vein in its course are numerous:—*parotid* branches, from the parotid gland; *articular*, from the articulation of the jaw; *anterior auricular* veins, from the external ear; and a vein of considerable size, the *transverse facial*, from the side of the face. This last-named vessel corresponds, *c*, with the transverse artery of the face. It courses backwards from the side of the face to the temporal vein. From the opposite direction the temporal vein receives the *posterior auricular*, *d*, which is itself joined by the stylo-mastoid vein.

Besides these, a branch of considerable size joins the temporal vein in the substance of the parotid gland; this is the *internal maxillary* vein, fig. 256, *e*, [v. maxillaris interna.] It corresponds somewhat in direction and position with the artery of the same name, and receives branches from the neighbouring parts, which are the venæ comites of the divisions of the internal maxillary artery. Thus three or four *deep temporal* branches descend from the temporal muscle; others come from the pterygoid, masseter, and buccinator muscles. The middle *meningeal* veins and some palatine veins also end in the internal maxillary; and lastly, branches from the surface of the upper jaw, and, of large size, from the lower jaw, emerging from the dental foramen (*inferior dental*). These different branches form a plexus of veins, named *pterygoid plexus*, which is placed in the lower part of the temporal fossa, between the temporal and the external pterygoid muscle, and in part between the pterygoid muscles. It communicates in front with the deep facial vein, and above, with the cavernous sinus by branches through the base of the skull. From this plexus proceed one or two short trunks (*internal maxillary*) which join nearly at right angles with the temporal vein.

The vessel formed by the junction of these different veins from the temple, maxilla, and face, may be called the *temporo-maxillary* vein; it descends in the interval between the ramus of the jaw and the sterno-mastoid muscle, and terminates in the external jugular vein, *f*, or partly in it and partly in the internal jugular vein.

EXTERNAL JUGULAR VEIN.

The *external jugular* vein, fig. 256, *f*, [v. jugularis externa] commences on a level with the angle of the lower maxilla, at the end of the temporo-maxillary vein, and therefore receives the greater part of the blood returned from the face and outside of the cranium. The external jugular vein descends perpendicularly between the platysma and sterno-mastoid muscles. In consequence of the oblique direction forwards of the last-named muscle, the vein gets to its outer border, close by which it continues down to the lower part of the neck, where it inclines inwards behind the muscle, to terminate (either as a single trunk, or by two or three branches) in the subclavian vein, *m*, near its junction with the internal jugular. In this course it receives one or two large branches from the back of the neck; one of these, *g*, (*posterior external jugular*,) lying at first between the splenius and trapezius, passes down at the outside of the jugular vein, and below the middle of the neck opens into it. Superficial branches also join it from the fore part of the neck. Some of these commence over the submaxillary gland, and some under the chin; by converging, they often form a vein of considerable size, *h*, which is then called the *anterior jugular* vein. This vessel lies along the fore part of the neck, sometimes near the sterno-mastoid muscle, and terminates either by inclining outwards to join the external jugular vein, or, after giving to it a branch of communication, sinks beneath the sterno-mastoid muscle, and ends in the internal jugular vein. Previously to the termination of the external jugular vein, two large veins open into it, derived from the region of

the scapula, *i*, (*supra-scapular* and *posterior scapular*.) Their direction is transverse from without inwards, lying parallel with the arteries of the same name.

As already mentioned, the external jugular vein is usually provided with two valves.

INTERNAL JUGULAR VEIN.

The *internal jugular* vein, fig. 256, *k*, [v. jugularis interna.]—The blood from the brain and cranial cavity is received by the internal jugular veins, which are continuous at their upper extremities with the lateral sinuses, whilst inferiorly they terminate in the innominate or brachio-cephalic veins. The commencement of each internal jugular vein at the lateral sinus is at the broad part of the foramen lacerum (*jugular fossa*). This part of the vessel, being somewhat enlarged, has been named the *sinus*, or *gulf* of the internal jugular vein. Beneath the skull, the vein is supported by the rectus lateralis muscle, and lies close at the outer side of the internal carotid artery, as far as the cornu of the os hyoides.

Being joined at this point by the common trunk formed by the union of the facial with a part of the temporal vein, the internal jugular vein becomes considerably enlarged, and then descends parallel with the common carotid artery, lying at its outer side and enclosed in the same sheath, together with the vagus nerve. At the root of the neck it joins nearly at a right angle with the subclavian vein, and so forms the innominate or brachio-cephalic vein. Previously to its junction with the facial vein, the internal jugular receives branches from the tongue, the pharynx, and the occiput. These branches, however, or some of them, are very frequently found to end in the common trunk of the temporal and facial veins. The *lingual* vein commences at the side and upper surface of the tongue, passes backwards, receiving branches from the sublingual gland; occasionally the ranine vein joins it, and sometimes also the pharyngeal. In either case it passes backwards between the mylo-hyoid and hyo-glossus muscles, to open into the internal jugular vein. The *pharyngeal* vein commences at the back and sides of the pharynx, and sometimes ends in the superior thyroid vein, and sometimes in the lingual, or separately in the internal jugular vein.

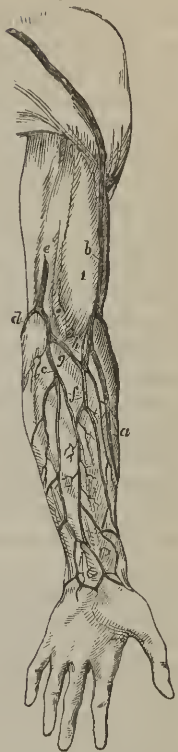
Corresponding in course and distribution with the occipital artery there is an *occipital* vein, which communicates with a plexus of veins upon the occiput, and terminates occasionally in the external jugular vein, but more frequently in the internal.

The *laryngeal* vein receives branches from the larynx through the thyro-hyoid membrane; they unite and form one vein, which opens into the internal jugular, or into the temporo-maxillary venous trunk, or sometimes into the superior thyroid vein.

The *superior thyroid* vein commences by branches in the thyroid body, in company with those of the superior thyroid artery. These unite and form a single vessel, which runs transversely outwards, and opens into the internal jugular vein. Lower down is found another branch (*middle thyroid*), also derived from the thyroid body.

VEINS OF THE UPPER LIMB.

Fig. 257.



The veins of the upper limb are divisible into two sets, one being superficial, the other deep-seated. Both these sets of veins, as high up as the axillary, and including that vein, are provided with valves, which are more numerous in the deep than in the subcutaneous veins. Valves are constantly to be found at the entrance of branches into the main vessels.

The *superficial veins.*—These are much the larger, and lie between the skin and fascia. Commencing on the dorsal surface of the fingers, they converge and communicate with one another on the back of the hand, so as to form a sort of plexus, from which issue two chief veins, that take, one the radial, the other the ulnar border of the fore-arm.

The *radial cutaneous* vein, fig. 257, *a*, [v. subcutanea radialis s. cephalica.]—The radial cutaneous vein commences by branches upon the dorsal surface of the thumb and fore-finger. These ascend over the outer border of the wrist, and form by their union a large vessel, which passes along the radial border of the fore-arm, receiving numerous branches from its anterior and posterior surfaces. At the bend of the arm it receives a branch from the median vein, (median-cephalic,) and then continues its course at the outer side of the upper arm, and is named "cephalic" vein.

The *cephalic* vein, *b*, thus formed, ascends along the outer border of the biceps muscle, and then in the interval between the great pectoral and deltoid muscles, and finally terminates in the axillary vein, between the coracoid process and the clavicle.

[Occasionally the cephalic vein is found passing over the clavicle and terminating in the jugular vein.]

The *ulnar cutaneous veins* [subcutaneæ ulnares, s. basilicæ].—There are two ulnar cutaneous veins, one on the front, the other on the back part of the fore-arm. The *posterior* ulnar cutaneous vein, *d*, begins on the back of the hand by branches, which unite to form a vein placed over the fourth metacarpal space, and called by some of the older anatomists "vena salvatella." This proceeds along the ulnar border of the fore-arm, at its posterior aspect, and, somewhat below the bend of the elbow, turns forwards to join with the anterior ulnar cutaneous vein. The *anterior* ulnar cutaneous vein, *c*, commences upon the anterior surface of the wrist, and thence ascends along the fore-arm, communicating by branches with the median vein on the one hand, and with the posterior ulnar cutaneous on the other. From the bend of the elbow upwards the trunk formed by the union of the two ulnar cutaneous veins assumes the name of "basilic vein."

The *basilic* vein, *e*, is usually of considerable size; it receives at its origin a branch from the median vein, *g*, (median-basilic,) and ascending along the inner border of the biceps muscle, in front of the brachial artery, terminates in one of the venæ comites of that vessel, or in the axillary vein, which it chiefly forms.

The *median cutaneous* vein [vena mediana] of the fore-arm, *f*, results from the union, on the anterior part of the fore-arm, of several branches. It is a short trunk, which serves as a means of communication between the ulnar and radial cutaneous veins on each side, as well as between the superficial and deep veins of the arm. Its length is subject to many varieties; it terminates by dividing into two branches, which diverge upwards from each other. One of these, inclining inwards to join the basilic vein, and thence named *median basilic*, *g*, passes in front of the brachial artery, from which it is separated by the fibrous expansion given by the tendon of the biceps muscle to the fascia covering the flexor muscles; it is crossed by branches of the internal cutaneous nerve: the other division, *h*, (*median cephalic*,) directed outwards, unites with the cephalic vein, branches of the external cutaneous nerve crossing behind this vein. The upper part of the median vein is also connected with the deep veins by a short branch, which sinks beneath the muscles, and joins the veins accompanying the brachial artery.

[As frequent an arrangement, as the division of the median vein into the median basilic and cephalic, is, for it to join a short trunk, usually varying from three to four inches, crossing over the aponeurotic slip from the tendon of the biceps at the bend of the arm, obliquely from the cephalic to the basilic vein. In such cases the median vein most usually forms a junction with the oblique trunk nearer to the basilic than the cephalic vein, and sometimes the median joins the basilic, and the oblique trunk terminates in it at its junction with the basilic. Occasionally the median vein preserves a distinct course up the arm, and terminates in the brachial or axillary veins.

In bleeding in the arm, the median basilic vein, or the oblique trunk nearer its junction with the basilic, is most generally chosen, because of its usually greater volume than the median cephalic or the oblique trunk near the cephalic; but the intelligent practitioner should keep it constantly in mind, that the external branch of the internal cutaneous nerve most usually passes over the median basilic or oblique trunk, near the basilic, and is liable to be cut. The external cutaneous nerve passes beneath the median cephalic vein.—J. L.]

The *deep veins of the upper limb.*—The brachial artery, its immediate branches, and their several divisions, are each accompanied by two veins, named *venæ comites.* These companion veins lie one on each side of the corresponding artery, and are connected with each other at intervals by short cross branches, which in some places surround the artery.

The *deep ulnar veins*, or the *companion veins* of the ulnar artery.—On examining the hand, it will be found that two small *digital* veins accompany each digital artery along the side of the phalanges. At the clefts between the fingers, the two small veins from each finger are united into single trunks, which continue together along the interosseous spaces in the palm of the hand, and terminate in the two *superficial palmar* veins. From this double venous arch two branches proceed at each side of the wrist, the external following the course of the superficial volar artery, whilst those on the inner side accompany

the ulnar artery. The two deep *ulnar* veins, commencing thus at the inner side of the superficial palmar arch, pass in front of the wrist, where they communicate with the interosseous and the superficial veins; then proceeding upwards along the inner side of the fore-arm, one on each side of the ulnar artery, they receive several branches from the neighbouring muscles; and, lastly, being joined by the veins which accompany the interosseous and ulnar recurrent arteries, unite with the deep radial veins to form the venæ comites of the brachial artery.

The *interosseous veins* consist of two sets (anterior and posterior), corresponding to the arteries with which they are associated. The *anterior* interosseous veins commence in front of the wrist-joint, where they communicate freely with the deep radial and ulnar veins. In their course upwards they are joined by several small branches, and are connected at the upper part of the fore-arm with the posterior veins by means of branches which pass through the interosseous membrane near the elbow-joint; after being joined by the posterior interosseous veins, they end in the venæ comites of the ulnar artery. The veins which accompany the *posterior interosseous* artery, previously to passing from behind to join with the anterior veins, communicate by their smaller branches with the ulnar cutaneous veins, and through branches accompanying the recurrent interosseous artery, with the cephalic vein.

The small branches which unite to form the *deep radial* veins run along the interosseous muscles in the palm of the hand; they are united in front with the digital veins previously described, and, at each end of the interosseous spaces, are connected by perforating branches with small veins situated on the back of the hand; by uniting across the bases of the metacarpal bones, they form a double venous arch corresponding with that formed by the radial artery. These *deep palmar* veins communicate on the inner side with the superficial arch of veins, and on the outer side end in the companion veins of the radial artery. The deep radial veins, in passing upwards to the fore-arm, receive at the wrist a dorsal branch, and one which passes over the small muscles of the thumb, with the superficial volar artery; then pursuing the course of the radial artery, they are joined by small veins from the surrounding parts, and end in the venæ comites of the brachial artery.

The two *brachial* veins, [venæ brachiales,] resulting from the union of the deep ulnar and radial veins just described, follow, like the several vessels of the same class, the course of the artery with which they are associated. They are joined in their progress, from the bend of the elbow upwards on the arm, by the veins which accompany the branches of the brachial artery, namely, the anastomotic and the two profunda arteries of the arm. At the lower margin of the axilla, the brachial veins unite to form the axillary; not unfrequently, however, one of them will be found to come forward and unite with the basilic, which soon becomes continuous with the axillary vein.

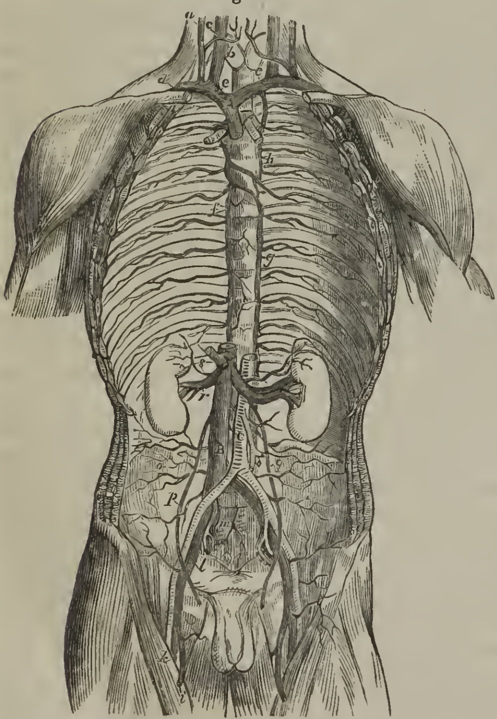
Between the several veins of the upper limb hitherto described, numerous connexions exist in their whole course. Thus, those which

lie beneath the integument are connected one to the other by branches in the hand and fore-arm. Each pair of companion veins is also united by short transverse vessels crossing the artery which they accompany, whilst between those attending different arteries frequent communications exist. Lastly, as has been in many instances specially indicated, the subcutaneous and the deep veins communicate freely, especially in the neighbourhood of joints. This general anastomosis insures the continuance of the circulation, during muscular action, in the frequent and varied motions of the limb.

AXILLARY VEIN.

The *axillary vein* [v. axillaris] extends, like the corresponding artery, from the lower border of the axilla to the outer margin of the first rib; it is covered by the pectoral muscles and the costo-coracoid membrane, and is placed to the inner side and in front of the axillary artery. The branches which open into the axillary vein are very numerous. It is formed below by the union of the companion veins of the brachial artery; it receives the subcutaneous veins of the arm —the basilic at its commencement, the cephalic towards its termination; it is also joined by the several veins corresponding with the branches of the axillary artery, viz., the two *circumflex* and the *subscapular* veins from the shoulder, the *alar* veins from the axilla, and the inferior, the superior, and acromial *thoracic* veins from the side of the chest. The axillary vein, therefore, returns all the blood from the upper limb: its size is very considerable, and it is the highest of the veins of the upper limb in which valves are found.

Fig. 258.



SUBCLAVIAN VEIN.

The *subclavian vein*, fig. 258, *d*, [v. subclavia,] is the continuation of the axillary, but, unlike it, has no valves. It extends from the outer margin of the first rib to the inner end of the clavicle, behind which it is joined by the internal jugular vein, *c*, the union forming the innominate

or brachio-cephalic vein, *e*. The subclavian vein crosses over the first rib, and behind the clavicle, not reaching so high up in the neck as the subclavian artery; it is covered by the clavicle, and by the subclavius and sterno-mastoid muscles, and lies on a plane anterior to the artery, from which, while resting on the rib, it is separated by the scalenus anticus muscle and the phrenic nerve.—On the outer side of the last-named muscle it receives the external jugular vein, and on its inner side the internal jugular. In their course to join the subclavian vein both jugular vessels pass in front of the subclavian artery, and add to the difficulty of placing a ligature on that vessel. The subclavian vein also receives the following branches.

The *vertebral vein* [v. vertebralis] commencing in branches which proceed from the pericranium and the deep muscles lying behind the foramen magnum of the occipital bone, passes outwards and downwards to reach the foramen in the transverse process of the atlas. Through this foramen, and through the canal formed by the corresponding foramina of the other cervical vertebræ, the vein next descends with the vertebral artery. Emerging at the foramen in the sixth vertebra, it runs forwards and downwards to join the subclavian vein, close to its termination; a small branch sometimes descends through the foramen in the seventh vertebra, and opens separately into the same vein. The vertebral vein is joined in its course by several branches from the neighbouring muscles; also, immediately before its termination, by a branch corresponding with the deep cervical artery; and in the same situation by another branch of considerable size, which descends in front of the bodies and transverse processes of the vertebræ of the neck. It communicates frequently with the spinal veins in the neck, both with those on the outer side, and those in the interior of the spinal canal.

The *superior intercostal* veins.—It sometimes happens that at the *right* side the veins corresponding with the superior intercostal artery pass downwards separately, to open into the azygos vein, as that vessel arches forwards to join the upper vena cava. When they unite to form a single vein, its size is much inferior to that on the left side. The *left superior intercostal* vein, fig. 258, *h*, varies in length in different persons, being small when the azygos minor is large, and *vice versâ*; usually the fifth intercostal branch turns upwards, and joins with or receives the fourth, third, second, and first, as it passes by the heads of the ribs. At the second vertebra, it inclines forwards and opens into the left innominate vein. It receives in its course the left bronchial vein. The sixth intercostal vein generally crosses the spine, and opens separately into the azygos vein; it communicates by a small branch with the small azygos vein, and also with the left superior intercostal vein.

The left superior intercostal vein often takes the opposite course to that which has been mentioned, being directed downwards, and in this case it joins the azygos vein. It has been seen to end in the azygos minor.

INNOMINATE OR BRACHIO-CEPHALIC VEIN.

The blood returned from the upper limbs through the subclavian veins, and from the head and neck by the jugular veins, is poured into two trunks, which are therefore named *brachio-cephalic.* These vessels, fig. 258, *e*, *e*, (called also *innominate*, [vena innominata] from their relation to the innominate arteries), resulting from the union of the subclavian with the internal jugular vein at each side, commence opposite the inner ends of the clavicles, and terminate a little below the cartilage of the first rib on the right side, where, by uniting, they form the upper vena cava, A. In consequence of the situation of the point at which they meet, the right and left brachio-cephalic veins differ considerably in direction, length and connexions. That of the right side is very short, and nearly vertical in its direction; this vein is in apposition, on the right side, with the upper part of the right lung. The vein of the left side, about three times longer than the preceding, is directed across from left to right, at the same time inclining somewhat downwards: it crosses behind the first bone of the sternum, separated from it by the sterno-hyoid and sterno-thyroid muscles, and by the thymus gland, when it exists, or some cellular tissue; it lies in front of the three primary branches given off from the arch of the aorta, and it rests upon the highest part of the arch. The innominate veins have no valves.

The *inferior thyroid* veins emerge from a sort of venous plexus on the thyroid body—those of opposite sides communicating by small branches across the trachea. The vein of the left side descends in front of the trachea, behind the sterno-thyroid muscles, and ends in the left brachio-cephalic or innominate vein: that of the right side inclines outwards in some degree, and opens into the corresponding brachio-cephalic vein, or into the angle of union between it and the vessel of the opposite side.

The *internal mammary* veins follow exactly the course of the arteries of the same name—two veins accompanying each branch of the arteries. The two companion veins of the artery arise by small branches, derived from the fore part of the walls of the abdomen, where they anastomose with the epigastric veins; from thence proceeding upwards behind the cartilages of the ribs between them and the pleura, they receive the *anterior intercostal* veins which correspond with the branches of the internal mammary artery, together with some small *diaphragmatic*, *thymic*, and *mediastinal* veins, and finally, after uniting into a single trunk, terminate—that of the left side in the left brachio-cephalic vein, that of the right side usually in the vena cava.

UPPER VENA CAVA.

The *upper vena cava*, fig. 258, A, [vena cava superior] conveys to the heart the blood which is returned from the head, the neck, the upper limbs, and the thorax. It extends from a little below the cartilage of the first rib on the right side of the sternum to the base of the heart, where it opens into the right auricle. Its course is slightly curved, the convexity of the curve being turned to the right side. It has no valves. At about an inch and a half above its termination, it

is invested by the fibrous layer of the pericardium, the serous membrane being reflected over it. The upper vena cava lies immediately in front of the right pulmonary vessels, and between the right lung and the aorta, which partly overlap it. It receives several small veins from the pericardium and the mediastinum, and lastly is joined from behind by the azygos vein.

In several instances, the two innominate veins, which usually join to form the vena cava superior, have been seen to open separately into the right auricle. The innominate vein of the right side, in these cases, continues in the ordinary course of the vena cava; whilst the left vein, after sending a branch across to the other, descends to the left side of the heart, and ends on the back of the right auricle, with the coronary vein.

This arrangement of the veins is natural in the fœtus at an early period, and is also met with as a permanent condition in birds and in certain mammalia.

AZYGOS VEIN.

The *azygos* vein (v. sine pari).—The name given to this vein signifies that it has no fellow or corresponding vessel (α priv. ζευγνυμι); but it cannot be applied with propriety, inasmuch as there is a similar though smaller vessel on the opposite side (azygos minor). The azygos vein, fig. 258, *f*, sometimes commences by a small branch either from the inferior cava, where that vessel turns forwards to reach the aortic opening in the diaphragm, but much more frequently it begins below from the lumbar veins (ascending lumbar) of the right side, or sometimes from the renal vein. Passing from the abdomen into the thorax, through the aortic opening in the diaphragm, or to the outer side of that opening, through the fibres of the diaphragm, the azygos vein ascends on the bodies of the dorsal vertebræ, until it arrives opposite the root of the right lung, over which it arches forward, and then opens into the upper vena cava, immediately above the point at which that vessel is invested by the pericardium. When passing through the opening in the diaphragm, this vein is accompanied by the thoracic duct, both being situated on the right side of the aorta. In the thorax, maintaining the same position with respect to the duct and the œsophagus, it crosses in front of the intercostal arteries, and is covered by the pleura. It is joined by the several veins which accompany the aortic intercostal arteries of the right side, and, at about the sixth or seventh dorsal vertebra, by the left or small azygos vein. It is also joined by several œsophageal and other small veins, and near its termination by the bronchial vein of the right lung; and higher up is connected with the left superior intercostal vein. As it communicates below with the vena cava inferior by one of the branches of that large vein, while it terminates in the vena cava superior, it forms a connexion between those two vessels. A few valves of imperfect formation have been found in the azygos vein; its branches (intercostal veins) are provided with distinct valves.

The *left* or *small azygos* vein, fig. 258, *g*, commences from one of

The azygos vein has been seen to receive the lower vena cava, and, in such cases, is of course extremely large (see p. 28).

In one instance, Meckel found the azygos ending in the subclavian vein.

the lumbar veins (ascending lumbar), or from the left renal vein, and having entered the thorax with the aorta, or through the crus of the diaphragm, ascends upon the spine in front of the left intercostal arteries, and, passing behind the aorta, opens into the azygos vein, opposite the sixth or seventh dorsal vertebra. It receives the lower intercostal veins of the left side.

All the intercostal veins of the left side have, in a few instances, been observed to join a single vein, which ended in the left innominate. This arrangement corresponded with that on the right side of the body.

The *bronchial veins* return the residue of the blood employed in the nutrition of the lungs. Their course is determined by that of the bronchi, which support them as they pass towards the root of the lungs. The bronchial vein of the right side opens into the azygos vein near its termination; that of the opposite side ends in the superior intercostal vein.

VEINS OF THE SPINE AND CRANIUM.

The part of the venous system contained within the skull and spinal canal, presents certain peculiarities deserving especial notice. *In the cranium* we find a series of sinuses, representing at once reservoirs and canals, interposed between the smaller venous branches and the large trunks (internal jugular) which transmit it towards the heart. The sinuses in the skull are formed between layers of the dura mater, their cavities being lined by a continuation of the internal membrane of the veins: they are very numerous, and vary considerably in form and size. Along the whole length of the *spinal canal* there is found a series of venous tubes or plexuses which present some analogy to the cranial sinuses, but which may be regarded as intermediate in character between those sinuses and the veins in other parts of the body. The spinal veins have no valves.

The veins within and upon the spinal column may be distinguished into the following sets: *a.* Those placed deeply in the vertebral grooves, and resting upon the spines and arches of the vertebræ. *b.* The veins of the spinal cord itself. *c.* Veins lodged within the bodies of the vertebræ. *d.* Two long series of veins, or rather venous plexuses, extended behind the bodies of the vertebræ the whole length of the canal. *e.* Veins on the fore part of the arches of the vertebræ.—There are likewise branches of communication, some of which connect all the other sets together, and some which bring them into connexion with the general venous system.

Preparation and Dissection.—The long spinal veins were first described by Chaussier; the veins of the cranial and spinal bones, as well as of the osseous system generally, were subsequently examined with great care by Dupuytren, and demonstrated in his lectures on anatomy. Breschet subsequently took up the subject.* In order to inject these vessels, an old and emaciated subject should be chosen, as the venous system becomes more developed in advanced age; it should be placed in a warm-bath in the usual way, and thoroughly warmed previous to injection. As the vessels cannot be filled from any single vessel,

* Essai sur les Veines du Rachis. 4to.—Traité Anatomique sur le Système Veineux. Fol. avec planches.

advantage must be taken of their numerous connexions to inject them from different points. With this view, an injecting pipe must be inserted into the upper longitudinal sinus, and others into the azygos vein, and into the upper and lower venæ cavæ. Through all these vessels the fluid for injecting should be pushed, and through at least two or three of them, if possible, at the same time. The posterior and external veins (if the injection has succeeded) are to be traced through the mass of dorsal muscles; those within the spinal canal are best seen by making a vertical section of the spine and skull, dividing them into two lateral halves; or the arches of the vertebræ may be cut out, and the cavity exposed.

a. The *dorsal veins* (dorsi-spinales,—Dupuytren, Breschet).—The blood from the muscles and integument placed along the back of the spine, is returned by a series of short veins, which ramify upon the arches and spinous processes of the vertebræ, and run forwards to terminate in some of the larger veins within the spinal canal. Commencing by small branches, they gradually increase in size as they run forwards, close by the spinous processes; on reaching the interval between the arches of the vertebræ, they pierce the ligamenta subflava, to terminate in a venous plexus within the canal. Towards the outer part of the intervertebral grooves another set of veins arise, which pass obliquely inwards, through the intertransverse spaces, in company with the posterior branches of the lumbar and intercostal arteries, and open into the veins which accompany those vessels.

b. The *veins of the spinal cord* (medulli-spinales,—Breschet) ramify upon the cord and its nerves, enclosed within the sheath formed by the dura mater. Though they communicate with the other spinal veins, they are not injected with them, even when the injecting process above described is most successful. Breschet gives the following as the best method of demonstrating them:

Preparation.—Let the injection consist of a strong solution of isinglass, coloured with indigo or Prussian blue: open the spinal canal in the lumbar region, slit up the dura mater, and search for one of the largest of the veins which rest upon the cord; into this pass the point of a very small injecting pipe and then cautiously push the injection, for the coats of the veins are exceedingly thin and weak.

The veins of the spinal cord are very small, long, and tortuous; they run upon both surfaces of the cord, where they form a diffused plexus or network. They become larger, for the most part, as they ascend, but near the base of the skull are smaller than in the lumbar region. They communicate freely with the spinal veins and plexuses, by means of branches which accompany the nerves towards the intervertebral foramina. Near the base of the skull these veins unite, and form two or three small trunks, which communicate by transverse branches with the vertebral veins, and then terminate in the inferior cerebellar veins, or in the petrosal sinuses.

c. The veins belonging to the bodies of the vertebræ (venæ basis vertebrarum,—Dupuytren; veines basi-vertébrales,—Breschet) are comparatively large vessels contained in the canals within the bodies of the vertebræ; the arteries which may accompany them being very small. About the middle of the posterior surface of each vertebra, (and this is especially evident in the dorsal and lumbar regions,) there is found a large foramen leading into a canal, which, running forwards into the substance of the bone for two or three lines, divides into two

smaller canals, which are directed towards each other, and often unite together. From this, still smaller canals pass obliquely forwards, some of which terminate in the cancelli of the bone, whilst others open upon its anterior or convex surface. Within these canals are situated the proper veins of the bodies of the vertebræ. They anastomose on the front of the bones with some of the superficial veins; and the trunk of each having reached the spinal canal divides into two branches, which diverge and terminate in the large spinal veins behind the bodies of the vertebræ.

d. The blood collected by the different vessels here described is poured by them into two large veins, or rather tortuous venous canals, which extend, one on each side, along the whole length of the spinal canal behind the bodies of the vertebræ. These vessels may be named the *great spinal veins* (grandes veines rachidiennes longitudinales antérieures,—Breschet). They are not of uniform size throughout, but are alternately constricted and enlarged, the constricted points corresponding with the intervertebral foramina, where they are drawn forwards, and in a manner secured by the branches of communication which pass outwards. This long series of veins lies behind the bodies of the vertebræ, occupying the interval at each side between the intervertebral foramina and the orifices seen at the back of the bodies of these bones. In some parts the veins are double, or even triple, so as to form a plexus; and occasionally they are altogether interrupted, which shows that each portion may be regarded as a separate trunk, receiving blood, and conveying it outwards into the general circulation, and that there is not necessarily an ascending or descending current along the venous column, formed by the entire series of veins. In the thoracic region their communicating branches open into the intercostal veins, in the loins into the lumbar veins, in the neck for the most part into the vertebral.

The *posterior spinal veins* (veines longitudinales rachidiennes postérieures,—Breschet). *e.* Besides this anterior set of veins within the spinal canal, there is a complex interlacement of tortuous veins established along the inner or anterior surface of the arches of the vertebræ. In the lower part of the canal this interlacement of veins is not so close as in the upper portion, where it usually conceals (if the injection has been successful) the whole surface of dura mater. These veins also converge to the intervertebral foramina, and open by rather small vessels with the intercostal veins.

From a consideration of the connexion and arrangement of the different parts of these complex veins, it would appear that the blood in each part flows through them horizontally from behind forwards. The dorsal veins pour their blood into the longitudinal plexus on the inner surface of the arches of the vertebræ; from thence it is collected by two or three small branches, which converge to the intervertebral foramina, and open into some of the veins outside the vertebral column in front, viz., into the lumbar, azygos, or cervical veins. Into these also, the contents of the great spinal veins are conveyed by the short communicating branches already noticed.

CEREBRAL VEINS.

The part of the venous system contained within the skull consists of veins, properly so called, and of certain cavities or channels called sinuses. The veins which return the blood from the brain are divisible into two sets, one being on the surface, the other in the interior of that organ. The superficial veins ramify upon every part of the surface of the brain, receiving branches on the one hand from its substance, and, on the other, terminating in the different sinuses. Upon the upper surface of the hemispheres the veins will be seen for the most part lodged in the tortuous sulci, between the convolutions; but some will be observed to run over the convexity of the convolutions. Their general direction is towards the middle line; and on reaching the margin of the longitudinal fissure between the hemispheres, they receive branches from the flat surface of the hemisphere, and, becoming invested by a tubular sheath of the arachnoid membrane, open obliquely forwards into the superior longitudinal sinus.

The veins upon the sides, and under surface of the brain, are similarly arranged; but are directed outwards, to open into the lateral sinuses at each side.

The deep veins of the brain commence by branches within the ventricles of that organ. Upon the surface of the corpus striatum, for example, several minute venous branches are seen, which for the most part converge, to form a slender vein which runs along the groove between the corpus striatum and optic thalamus, and opens into one of the veins of the choroid plexus. The minute veins of the choroid plexus pass backward, and incline towards the middle line from each side, so as to form, by their union, two veins (*venæ Galeni*). These, lying parallel, run directly backwards, enclosed within the velum interpositum, and escape from the ventricle by passing through the great transverse fissure of the brain between the under surface of the corpus callosum and tubercula quadrigemina. In this way they reach the anterior margin of the tentorium cerebelli, at its place of union with the falx cerebri, where they terminate by opening into the straight sinus.

The *veins of the cerebellum* are disposed in two sets, not merely from a reference to their position, but also from a consideration of their direction and termination. Those of the upper surface incline inwards and forwards for the most part, and will be found to run upon the upper vermiform process, over which they ascend a little to reach the straight sinus, in which they terminate; some, farther forward, open into the veins of Galen. Those at the under surface run transversely outwards, and pour their contents into the two lateral sinuses.

CRANIAL SINUSES.

The sinuses placed within the cranial cavity, are interposed between the cerebral veins and the internal jugular veins, which receive the blood from them. There are several of these canals, and, by reason of a difference in their position, they admit of being divided into two

sets, viz., those placed in the prominent folds of the dura mater, and those disposed at the base of the skull.

The form and size of the sinuses are various. All of them are lined by a continuation of the internal membrane of the veins, the dura mater serving as a substitute for the external coat.

The sinuses which are contained in the several processes or folds of the dura mater converge to a common point, which corresponds with the internal occipital protuberance, and is called the *confluence of the sinuses*, or *torcular Herophili*, fig. 259, *a*; fig. 260, *i*: its form is very irregular. If a square piece of bone be removed, and the dura mater be laid open at the point above referred to, six apertures leading to the following sinuses will be observed opening into it: viz., one to the longitudinal, and one to the straight sinus; two to the right and left lateral sinuses; and two to the posterior occipital sinuses.

The *superior longitudinal sinus*, fig. 259, *b* (sinus longitudinalis; s. falciformis superior,) commencing at the crista galli, extends from before backwards, in the upper border of the falx cerebri, gradually increasing in size as it proceeds. Across its cavity, which is triangular, several bands (*chordæ Willisii*) extend obliquely. The veins from the cerebral surface open into this sinus in such a way that the apertures of the greater number of them are directed from behind forwards, contrary to the direction of the current within it. The longitudinal sinus communicates with the veins on the outside of the occipital bone, by a branch (one of the "emissary veins," Santorini) which passes through a hole in the parietal bone.

Fig. 259.

The *inferior longitudinal sinus*, fig. 259, *c* (s. falciformis inferior; sinus longitudinalis inferior), is very small; it is circular in the form of its cavity, and so much resembles a vein, that it is sometimes named *inferior longitudinal vein.* Placed in the inferior concave border of the falx cerebri, it runs from before backwards, and opens into the straight sinus on reaching the anterior margin of the tentorium cerebelli. It receives branches from the surface of the falx cerebri, and sometimes from the flat surface of the middle and posterior lobes.

The *straight sinus*, fig. 259, *d* (s. quartus; s. tentorii).—This sinus may be considered as the continuation of the inferior longitudinal sinus; it runs backwards in the direction of the base of the falx cerebri, gradually widening as it approaches the torcular Herophili, in which it terminates. Its form is triangular; some transverse bands cross its interior. Besides the inferior longitudinal sinus, the venæ Galeni, *e*, and the superior veins of the cerebellum, open into it.

The lateral sinuses, fig. 259, *f*; fig. 260, *h*, (sinus laterales; s. trans-

versi,) are of considerable size. Their direction conforms to that of the groove marked along the inner surface of the occipital and other bones, from opposite the internal occipital protuberance to the foramen lacerum posterius. The sinus of the right side is usually larger than that of the left; both commence at the torcular Herophili, and terminate at the outlet just noticed, where they are continuous with the jugular veins. The lateral sinuses receive the blood transmitted from both the longitudinal sinuses, from the straight and occipital sinuses, and also that from the veins upon the sides and base of the brain, from those on the under surface of the cerebellum, and from some of the veins of the diploe. The petrosal sinuses also join the lateral sinus on each side; and two emissary veins connect these with the veins at the back of the head and neck.

The *posterior occipital sinus*, fig. 259, *g*; fig. 260, *g*, (sinus occipitalis posterior,) is sometimes a single canal, not unfrequently double, as if composed of two compartments. It lies along the attached border of the falx cerebelli, extending from the posterior margin of the foramen magnum to the confluence of the sinuses. It communicates in front with the posterior spinal plexuses of veins.

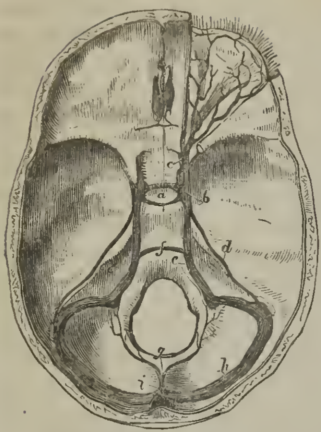
The sinuses placed at the base of the skull are as follows, taking them in their order from before backwards:

The *circular sinus*, fig. 260, *a* (sinus circularis,—Ridley).—The name expresses its form; its position is around the margin of the pituitary fossa. It is not always a complete ring, as it represents sometimes a semicircle, placed usually before the gland, sometimes behind it. This small sinus receives the blood from the minute veins of the pituitary body. It communicates at each side with the cavernous sinus.

The *cavernous sinuses*, fig. 260, *b*, [sinus cavernosi,] two in number, are placed one on each side of the body of the sphenoid bone. They are of a very irregular form, but of considerable size. Each receives the ophthalmic vein at its fore part, and communicates internally with the circular sinus, and posteriorly with the petrosal sinuses. The dura mater at the side of the body of the sphenoid bone divides into two layers; one of these rests on the bone, whilst the other is stretched from the margin of the sphenoidal fissure backwards, to the upper border of the petrous portion of the temporal bone; so that the two layers leave an interval between them, constituting the sinus. The membrane which lines the ophthalmic vein and the circular sinus, passes into the cavity now under consideration; it is intimately connected with that layer of the dura mater which forms the inner wall of the sinus, but is separated from the outer wall by an interval in which are found the carotid artery, with the third, fourth, ophthalmic division of the fifth, and the sixth nerves.

The *upper petrosal sinus*, fig. 259, *h*; fig. 260, *d*, [sinus petrosus superior,] is a narrow venous canal, running along the upper margin of the petrous part of the temporal bone. Commencing at the back part of the cavernous sinus, it is directed outwards and backwards in the attached margin of the tentorium cerebelli; and descending a little, ends in the lateral sinus, where it lies upon the temporal bone.

Fig. 260.



The *lower petrosal sinus*, fig. 259, *i*; fig. 260, *e*, [s. petrosus inferior,] larger than the preceding sinus, is very near that sinus at its anterior end; but is afterwards lower down, and to its inner side. Commencing at the cavernous sinuses, the lower petrosal sinus passes downwards and backwards very near it, taking the direction of the inferior margin of the petrous bone, between it and the basilar process of the occipital bone. It opens into the lateral sinus near its termination, or into the internal jugular vein.

The *anterior occipital* or *transverse sinus*, fig. 260, *f*, (sinus basilaris).—This is placed at the fore part of the basilar process of the occipital bone, and is rather a plexus of veins than a sinus, which reaches transversely, so as to establish a communication between the inferior petrosal and the cavernous sinuses.

OPHTHALMIC VEIN.

The *ophthalmic vein*, fig. 260, *c*, [v. ophthalmica,] may be described in connexion with the veins of the cranium as it opens into the cavernous sinus. Its branches are distributed in the different structures contained within the orbit, in company with the branches of the ophthalmic artery. Some small ramifications arise from the eyelids, whilst others communicate with the angular branch of the facial vein; those which accompany the supra-orbital artery have similar connexions with the veins upon the forehead. All these branches, together with others arising from the lachrymal gland, from the different muscles, from the ethmoidal cells, those from the globe of the eye itself, all named according to the arterial branches which they accompany, join to form a short single trunk, which leaves the orbit by the inner part of the sphenoidal fissure, and terminates in the cavernous sinus.

VEINS OF THE DIPLOE.

The veins of the cranial bones, *veins of the diploe*, [v. diploicæ,] are only to be seen after the pericranium is detached, and the external table of the skull carefully removed by aid of a file. Lodged in proper canals hollowed in the substance of the bones, their branches form an irregular network, from which a few larger vessels issue. These are directed downwards at different parts of the cranium, and terminate, partly in the veins on the outer surface of the bones, and partly in the lateral sinuses, or the posterior occipital sinuses. Amongst them may be recognised generally, a *frontal* vein of the diploe; two *temporal*, one anterior ramifying in the frontal bone, and one posterior chiefly coming from the parietal bone; and lastly, the largest vein of the diploe, that ramifying in the occipital bone.

OF THE VEINS WHICH FORM THE LOWER VENA CAVA.

The branches which unite to form the lower vena cava return the blood from the lower limbs, and from the viscera of the pelvis and abdomen.

The veins of the lower limb, as in other parts of the body, are divisible into two sets, of which one is deeply-seated, whilst the other runs between the common integument and the fascia. All the veins of the lower limb, as high as the femoral venous trunk, are provided with valves, and they are said to be more numerous than in the veins of the upper limb. The deep veins have more valves than the subcutaneous set; and each branch has two valves placed to guard its entrance into a larger trunk. Immediately beneath the integument on the dorsum of the foot there exists a network of small veins, from which issue two principal trunks (saphenous), which are named, from their relative position, internal and external, or, from their relative length, the long and short.

Fig. 261.

The *long* or *internal saphenous* vein, fig. 261, [v. saphena magna s. interna,] extends from the ankle to within an inch and a half of Poupart's ligament; in this course it lies between the integument and the fascia. Taking rise from the plexus of veins on the dorsum of the foot, it passes upwards in front of the inner ankle, and thence along the corresponding border of the tibia, accompanied by the internal saphenous nerve. At the knee, the vein inclines a little backwards as it passes by the inner condyle; after which it ascends along the inner and fore part of the thigh, and terminates in the femoral vein, after passing through an aperture, 1, in the fascia lata, which, from this circumstance, has been termed the *saphenous opening*. It is joined in this long course by numerous cutaneous branches, and near its termination receives the *superficial epigastric*, *a*; *external pudic*, *b*; and *superficial circumflex iliac veins*, *c*; the former passing down from the abdomen between the layers of the superficial fascia, the latter from the groin and pubes. This long vein has a variable number of valves. Sometimes six sets have been counted. In other cases only four, or even two. There are more in its course through the thigh than in the leg.

The *external* or *short saphenous* vein [v. saphena minor, s. posterior] proceeds from branches, *d*, which arise along the outer side of

the dorsum of the foot, and passes behind the outer ankle, gradually inclining backwards to the tendo Achillis. Passing along the border of the tendon, it gets on the belly of the gastrocnemius muscle, fig. 262, on which it ascends, accompanied by the external saphenous nerve; with the nerve it runs between the heads of the gastrocnemius, and pours its contents into the popliteal vein.

The *deep veins* of the lower limb accompany the arteries and their branches, following exactly their distribution. Those below the knee being for the most part disposed in pairs, and presenting the disposition described in the corresponding veins of the upper limb, are named the *venæ comites* of the vessels with which they are associated. The venæ comites of the arteries of the leg, namely, the *anterior* and *posterior tibial veins* (the latter having previously received the *peroneal*), unite near the lower border of the popliteus muscle, and form by their junction the popliteal vein. The valves of the deep veins of the leg are very numerous,—ten or twelve sets being sometimes found between the heel and the knee.

Fig. 262.

The *popliteal vein*, thus formed, receives branches corresponding with the articular and muscular arteries; but its chief branch is the external saphenous vein. In its course through the ham, the popliteal vein is placed behind and to the outer side of the artery, that is to say, between it and the nerve. Thus situated, it passes up through the aperture in the adductor magnus, and becomes continuous with the femoral vein.

The union of the veins which form the popliteal is often delayed, and the lower part of the artery is accompanied by two veins. This arrangement in some cases extends to the entire length of the artery.

FEMORAL VEIN.

The *femoral* vein, fig. 258, *k*, [v. femoralis, s. cruralis,] extends, like the artery which it accompanies, through the upper two-thirds of the thigh. Placed at first behind that vessel, it gradually inclines inwards and forwards, so that on reaching Poupart's ligament (where it terminates in the iliac vein) it lies on the inner side, and on the same plane as the artery, being separated from it only by a slight partition which passes from before backwards, across the membranous sheath investing them both. In the lower part of its course, the vein receives all the venous branches which accompany the ramifications of the arteries. In the upper part, the deep femoral vein opens into it, having first received all the branches from muscles supplied by the deep femoral artery. Near its termination the femoral vein is joined by the internal saphenous vein, fig. 258, *i*.

The femoral vein occasionally pursues a different course from the artery along the thigh. Extending upwards from the popliteal space, the vein in such cases perforates the adductor magnus above the ordinary position, and joining with the deep femoral vein first approaches the femoral artery at the groin. The same vein is now and then double in a small part, or more rarely in almost its whole length.

EXTERNAL ILIAC VEIN.

The femoral vein, placed at the inner side of the artery, enters the abdomen beneath Poupart's ligament, and assumes the name of *external iliac* vein, fig. 258, *l*, [v. iliaca externa.] This vessel, lying at first on the inner side, and on the same plane with the external iliac artery, gradually inclines somewhat behind it in approaching the sacro-iliac junction, where it joins the internal iliac vein, to form the common iliac vein. Near its commencement at Poupart's ligament, the external iliac vein receives the circumflex iliac and epigastric veins. It is not provided with valves.

INTERNAL ILIAC VEIN.

The *internal iliac* vein, fig. 258, *m*, [v. iliaca interna, s. hypogastrica.]—All the branches of the internal iliac artery are accompanied by veins, except the umbilical, whose corresponding vein passes in the fœtus upwards to the liver: these several veins give rise to the internal iliac. The vessel thus formed lies behind the corresponding artery in front of the sacro-iliac junction, and, after a very short course upwards to the margin of the pelvis, joins with the external iliac vein to form the common iliac. It returns the blood from the organs contained within the pelvis, and from the large mass of muscles which occupy its outer surface. The branches of this vein follow the course of the arteries derived from the internal iliac artery, and, being remarkable for their size and their frequent anastomoses one with the other, they have been described as forming a series of plexuses, severally named from the organs on which such interlacement occurs: thus the vesical, hæmorrhoidal, and uterine plexuses, are not unfrequently mentioned. No valves are found in the internal iliac vein, but its branches are provided with them.

The *dorsal* vein of the *penis*, a vessel of considerable size, requires a special notice. Commencing by a series of branches which issue from the glans penis, we find in the first instance two, one at each side of the middle line, in the dorsal groove of the penis; they receive branches from the corpus cavernosum, and some superficial veins which accompany the external pudic arteries. Proceeding backwards, they unite and form a short trunk which enters the pelvis beneath the subpubic ligament. Here it divides into two branches, which are directed obliquely downwards over the prostate and neck of the bladder, where they anastomose with branches of the vesical veins, forming a sort of plexus, and finally open into the internal iliac vein.

COMMON ILIAC VEIN.

Each *common iliac* vein, [v. iliaca communis,] formed by the confluence of the external and internal iliac veins, passes upwards; and the vein of the left side inclines towards the corresponding vessel of the opposite side. Near the junction of the fourth with the fifth lumbar vertebra, a little to the right of the middle line, the two common iliac veins unite to form the lower or ascending vena cava. The right vein is shorter than the left, and is nearly vertical in its direction. The right vein is placed behind, and then to the outer side of its artery,

whilst the left vein is to the inner side of the left common iliac artery. Both pass behind the right common iliac artery.—These veins are destitute of valves.

LOWER VENA CAVA.

The *lower vena cava* (vena cava inferior, ascendens), fig. 258, B, returns the residue of the blood circulated by the abdominal aorta. It commences at the junction of the two common iliac veins on the side of the fourth lumbar vertebra, and thence ascends along the right side of the aorta, as far as the posterior border of the liver; it there becomes lodged in a groove in that organ, after which it inclines forwards to reach the opening in the diaphragm appropriated to it, and, having passed through the pericardium, terminates in the right auricle of the heart. It has one large valve at its entrance into the auricle, named the valve of Eustachius. In its course it receives the lumbar and renal veins; also the spermatic, capsular, and phrenic veins; and, finally, the hepatic veins, which, through the medium of the portal system, return the blood circulated through the chylopoietic viscera.

The lower vena cava presents some occasional deviations from its ordinary condition, which may be briefly noticed.

Thus, in the lower part of its course, it is sometimes placed to the left side of the aorta, and, after receiving the left renal vein, resumes its ordinary position by crossing over the great artery. Less frequently, the vena cava is placed altogether on the left side, and is continued upwards to the heart, without any change in its direction; the thoracic and abdominal viscera being, in such cases, transposed, as well as the great vessels.

In another class of cases, more numerous than those just mentioned, the left common iliac vein, instead of joining the right in its usual position, is connected with it only by a small branch, and then ascends on the left side of the aorta. After receiving the left renal vein, it crosses over the aorta, and terminates by uniting with the common iliac vein of the right side. In these cases, the vena cava inferior can be said to exist only at the upper part of the abdomen, and below this point there is a vein on each side of the aorta.

Lastly, the lower vena cava, instead of ending in the right auricle of the heart, has been seen to join with the azygos vein, which is then very large; so that the blood from the lower, as well as from the upper part of the body, enters the heart through the upper vena cava. In this case, the hepatic veins do not join the lower cava, but end at once in the right auricle, at the usual place of termination of the great vein. [A preparation, exhibiting this anomalous arrangement, is preserved in the Wistar Museum.*]

The *middle sacral* vein, fig. 258, *n*, taking its course upwards on the front of the sacrum, opens into the commencement of the vena cava, or more usually into the left common iliac vein.

The *lumbar* veins, fig. 258, *o*, commence by small *dorsal* branches in the muscles of the back, and by others from the walls of the abdomen, where they communicate with the epigastric and other veins in the neighbourhood. Having reached the spine, they receive branches from the *spinal* plexuses: they proceed forward upon the bodies of the vertebræ, behind the psoas muscle, those on the left side passing behind the aorta, and terminate in the back of the vena cava. Some of these veins are frequently found to unite into a single trunk before their termination.

The lumbar veins of the same side communicate with each other by branches which cross in front of the transverse processes. One

[* Described by Dr. Horner in the "Journal Acad. Nat. Sci.," vol. i. p. 401. Phil. 1817.]

branch is not unfrequently met with, called the *ascending lumbar* vein, which connects more or less completely the common iliac vein, the ilio-lumbar and lumbar veins, and the azygos vein.

The *spermatic* veins, fig. 258, *p*, *q*, proceeding upwards from the testicle, and forming one of the constituents of the spermatic cord, enter the abdomen, and ascend on the psoas muscles, behind the peritonæum. Below the abdominal ring the veins are numerous, branched and convoluted; they form a plexus, named the *spermatic plexus* (plexus pampiniformis); they have valves, but still may be injected from above downwards. These branches gradually unite, and form a single vessel, which opens on the right side into the lower vena cava, and on the left into the renal vein. The spermatic veins sometimes bifurcate before their termination, each division opening separately; in this case, the veins of the right side may be found communicating with the vena cava and the renal vein. In the female, the *ovarian* veins have the same general course as the ovarian arteries; they form a plexus near the ovary (ovarian or pampiniform plexus) in the broad ligament, and communicate with the uterine plexus.

Valves exist in the spermatic veins in man (Monro); and, in exceptional cases, they have been also seen in the ovarian veins (Theile).

The *renal* or *emulgent* veins, fig. 258, *r*, are short, but of very considerable size. That of the left side is longer than the right, and passes generally in front of the aorta. They join the vena cava at nearly a right angle. The renal veins usually receive branches from the suprarenal capsules; the left has also opening into it the spermatic vein of the same side.

The *capsular* or *suprarenal* veins, fig. 258, *s*, though small, are, proportionately to the organs from which they arise, of considerable size. On the right side they usually end in the vena cava, and on the left in the renal or phrenic vein.

The *phrenic* veins follow exactly the course of the arteries supplied to the diaphragm by the abdominal aorta.

PORTAL SYSTEM OF VEINS.

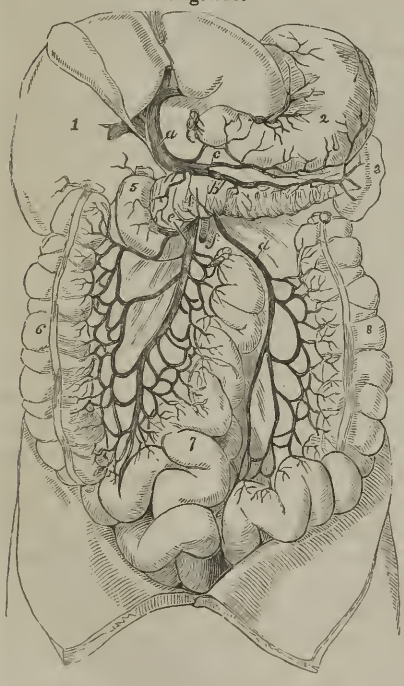
In the adult, as well as in the fœtus, the veins of the liver present peculiarities which distinguish them from the rest of the venous system; for in this organ a large venous trunk, performing, as it were, the function of an artery, conveys materials from which, at least in great part, the peculiar secretion of the organ is elaborated. The portal vein (vena portæ), for so is this large venous trunk named, has been so called from its entering the liver at its transverse fissure, which was likened to a gateway, the small lobes placed before and behind it representing its pillars. The portal vein is thus formed: the veins from all the chylopoietic viscera unite into two principal trunks, named the splenic and superior mesenteric veins; from the junction of these two veins results the vena portæ. Having reached the liver, the portal vein again divides and ramifies in the substance of that gland, so that it may be said to have two sets of branches: one, branches of commencement in the intestines, and the other, branches of termination in the liver; both being connected by an intermediate

trunk. Both kinds of branches are in all cases single, and destitute of valves. The entire system of these veins, from the intestines to the liver, is named the *portal system.*

The *splenic* vein, fig. 263, *b*, is a vessel of very considerable size, for it returns the blood not only from the spleen, but also from the pancreas, the duodenum, the greater part of the stomach and omentum, the descending colon, and part of the rectum. It commences by five or six branches, which issue separately from the fissure of the spleen, but soon join to form a single vessel. It is directed from left to right, embedded in the substance of the pancreas, in company with the splenic artery, beneath which it is placed. On reaching the front of the spine it joins the superior mesenteric vein, nearly at a right angle. It receives gastric branches (vasa brevia) from the left extremity of the stomach, the *left gastro-epiploic* vein, *c*, some pancreatic and duodenal branches, and also the two following veins, which require a more detailed notice:

The branches of the *inferior mesenteric* vein, fig. 263, *d*, correspond with the ramifications of the artery of the same name. They commence behind and at the sides of the rectum, from which they ascend and unite into a single vessel, near the sigmoid flexure of the colon. From this point the vein passes upwards and inwards along the lumbar region, behind the peritoneum, crossing between the transverse mesocolon and the spine; sometimes it lies farther to the left, but in either case it passes beneath and behind the pancreas, so as to reach the splenic vein, in which it terminates.

Fig. 263.



The *coronary* vein of the stomach lies parallel with the artery of the same name. Its size is inconsiderable, and its direction transverse from the cardiac to the pyloric end of the stomach, along the lesser curvature. On reaching the latter point it turns downwards, and opens into the splenic vein, or in some instances into the trunk of the vena portæ.

The *superior mesenteric* vein, fig. 263, *e*, lies to the right side, and somewhat in front of the artery of the same name. The distribution of its branches corresponds with that of the superior mesenteric artery, and it returns the blood from the several parts supplied by that vessel, viz.,

from the small intestine, and from the ascending and transverse parts of the colon. The trunk formed by the union of its several branches inclines upwards and to the right side, passing in front of the duodenum and behind the pancreas, where it joins with the splenic vein.

PORTAL VEIN: VENA PORTÆ.

The trunk of the *portal vein*, fig. 263, *a*, commencing at the junction of the splenic and mesenteric veins, passes upwards, forwards, and a little to the right, to reach the transverse fissure of the liver, being about three inches in length. It is placed close behind, and between the hepatic artery and the hepatic ducts. It is surrounded by the filaments of the hepatic plexus of nerves, together with numerous lymphatics. All these are embedded in loose cellular tissue, and enclosed within the layers of the gastro-hepatic omentum. Within the transverse fissure it is somewhat enlarged, and is there named *sinus of the portal vein.* Near the right end of the transverse fissure, the vena portæ divides into two branches. That of the right side enters directly the substance of the corresponding lobe of the liver, and spreads out into branches, each of which is accompanied by a branch of the hepatic artery and of the hepatic duct. The left branch, which is smaller, but necessarily longer, passes across to gain the left end of the transverse fissure, where it enters the liver and ramifies like the preceding branch. The blood conveyed to the liver by the branches of the portal vein is collected again and returned into the current of the circulation by the hepatic veins.

The *hepatic* veins, fig. 263, *t*, commence in the capillary terminations of the vena portæ. Their branches gradually unite and become large as they pass backwards and upwards, towards the back part of the liver, where the lower vena cava passes in a groove behind that organ. At this point they all end in the vena cava, passing obliquely into that vein. There are usually three sets of hepatic veins proceeding to this common point; those from the right and left lobes being oblique in their direction, those from the middle of the liver and the lobule of Spigelius having an intermediate position and course.

The hepatic veins run singly, and have no companion arteries. The branches of the hepatic arteries ramify in the liver along with the portal veins. The hepatic veins have no valves; but, owing to their oblique entrance into the vena cava, a semilunar fold is seen at the lower border of the orifice of each vein.

The hepatic veins sometimes, though rarely, enter at once into the auricle of the heart—the vena cava inferior, in these cases, joining the azygos vein.

In a remarkable case, observed by Rothe,* one of the hepatic veins ended, not in the lower cava, nor in the right auricle, but in the right *ventricle* of the heart, its orifice being guarded by valves.

VEINS OF THE HEART.

The veins of the heart (*cardiac* veins) are recognised as four in number, and named according to their relative size. They are all single veins, and have no valves in their course.

* Act. Acad. Joseph. Med.-Chir. Vindobonensis, t. i. p. 233, tab. 5. Vindobonæ, 1788.

The *great cardiac* vein (vena cordis magna) is a vessel of considerable size, and from the way in which it coils round the left side of the base of the heart, or rather of the ventricle, it may be named "coronary." Its chief branch runs along the groove upon the fore part of the heart, corresponding with the septum of the ventricles. Commencing at the apex of the heart, it gradually increases in size as it approaches the base of the ventricles, and then inclining backwards and to the left side, runs in the groove between the left auricle and ventricle, and prolonging its course a few lines beyond this groove, opens into the right auricle, close to the interauricular septum. In this course it receives branches from the ventricles, especially from the left, and also from the left auricle; and when it passes by the thick margin of the left ventricle, it receives a vein of some size, which ascends to join it. At the entrance of this vein into the auricle, is situated a semilunar fold of the lining membrane, or valve, named *valvula Thebesii.*

The *middle cardiac* vein (vena cordis media).—The term "coronary" cannot be applied to this vessel, as its direction is straight, along the groove between the ventricles upon the posterior surface of the heart. It commences by small branches at the apex of the heart, which communicate with those of the preceding vein, then ascends to the base, receiving branches from the substance of both ventricles, and opens into the *great vein* near its termination.

The *small* or *anterior cardiac* veins (venæ cordis parvæ) are several small branches, which commence upon the anterior surface of the right ventricle, and pass upwards and outwards, opening separately into the right auricle, after having crossed over the groove between it and the ventricle.

The *smallest cardiac* veins (venæ cordis minimæ).—Under this name are included numerous minute vessels, the orifices of which are observable on the inner surface of the right auricle. From having been noticed by an old anatomist, Thebesius, these openings are called *foramina Thebesii.* Some of these openings do not appear to be mouths of veins, but only of small depressions in the wall of the auricle.

LYMPHATIC SYSTEM.

THE LYMPH AND CHYLE.

A transparent, and nearly colourless fluid, named "lymph," is conveyed into the blood, by a set of vessels distinct from those of the sanguiferous system. These vessels, which are named "lymphatics" from the nature of their contents, and "absorbents" on account of their reputed office, take their rise in nearly all parts of the body, and after a longer or shorter course, discharge themselves into the great veins of the neck; the greater number of them previously joining into a main trunk, named the thoracic duct,—a long narrow vessel which rises up in front of the vertebræ, and opens into the veins on the left side of the neck, at the angle of union of the subclavian and internal jugular: whilst the remaining lymphatics terminate in the corresponding veins of the right side. The absorbents of the small intestine carry an opaque white liquid, named "chyle," which they absorb from the food as it passes along the alimentary canal; and, on account of the milky aspect of their contents, they have been called the "lacteal vessels." But in thus distinguishing these vessels by name, it must be remembered, that they differ from the rest of the absorbents only in the nature of the matters which they convey; and that this difference holds good only while digestion is going on: for at other times the lacteals contain a clear fluid, not to be distinguished from lymph. The lacteals enter the commencement of the thoracic duct, and the chyle, mingling with the lymph derived from the lower part of the body, is conveyed along that canal into the blood.

Both lacteals and lymphatics, in proceeding to their destination, pass through certain small, solid and vascular bodies, named lymphatic glands, in which they are in some degree modified in structure and arrangement, as will be afterwards described; so that both the chyle and lymph are sent through these glands before being mixed with the blood.

This much having been explained to render intelligible what follows, we may now consider the lymph and the chyle, which, as will be seen, are intimately related to the blood.

LYMPH.

The lymph may be procured free from admixture of chyle, and in quantity sufficient for examination, from the larger lymphatic vessels of the horse or ass. It may also be obtained, by opening the thoracic duct of an animal that has fasted for some time before being killed. It is a thin fluid, transparent and colourless, or occasionally of a pale

yellow hue; its taste is saline, its smell faint and scarcely perceptible, and its reaction alkaline. Sometimes the lymph has a decided red tint, of greater or less depth, which becomes brighter on exposure to the air. This redness is due to the presence of coloured corpuscles, like those of the blood: and it has been supposed, that such corpuscles exist naturally in the lymph, in greater or less quantity; but Mr. Lane,* who has lately investigated the point, concludes, that they are introduced into the lymphatic vessels accidentally; he adduces an experiment to show, that when an incision is made into a part, the blood will very readily enter the lymphatics which are laid open, and pass along into larger trunks; and he conceives, that in this way blood is conveyed into the thoracic duct, or any other large vessel, exposed as usual by incision immediately after the animal is killed.

The lymph, when examined with the microscope, is seen to consist of a clear liquid, with corpuscles floating in it. These "lymph corpuscles," or lymph globules, agree entirely in their characters with the pale corpuscles of the blood, which have been already described. Occasionally, smaller particles are found in the lymph; also, but more rarely, a few oil globules of various sizes, as well as red blood corpuscles, the presence of which has just been referred to.

The liquid part (lymph-plasma), bears a strong resemblance in its physical and chemical constitution to the plasma of the blood: and, accordingly, lymph fresh drawn from the vessels coagulates after a few minutes' exposure, and separates after a time into clot and serum. This change is owing to the solidification of the fibrin contained in the lymph-plasma, and in this process most of the corpuscles are entangled in the coagulum. The serum, like the corresponding part of the blood, consists of water, albumen, extractive matters, fatty matters in very sparing quantity, and salts.

Human lymph has been obtained fresh from the living body in two instances, in which a lymphatic vessel had been accidentally opened by a wound. It has been found to agree in all material points with the lymph of quadrupeds. Its specific gravity, in the case examined by Marchand and Colberg, was 1037.

The following analyses exhibit the proportion of the different ingredients; but it must be explained, that the amount of the corpuscles cannot be separately given, the greater part of them being included in the clot and reckoned as fibrin.

Lymph of the ass from the lymphatics of the posterior limb, (by Dr. G. O. Rees):†—

Water	96·536
Albuminous matter	1·200
Fibrinous matter	0·120
Extractive matter soluble in water and alcohol	0·240
Extractive matter soluble in water only	1·319
Fatty matter	a trace
Salts, viz.—Alkaline, chloride, sulphate, and carbonate, with traces of alkaline phosphate, oxide of iron	0·585
	100·

* Cyclopædia of Anatomy, art. Lymphatic System.
† Medical Gazette, Jan. 1, 1841.

Lymph from the lumbar lymphatics of the horse (Gmelin):—

Water	96·10
Dried clot (fibrin, with corpuscles)	0·25
Dried serum, 3·65, viz.	
Albumen	2·76
Extractive matter soluble in alcohol (osmazome), with alkaline chloride, and acetate	0·69
Extractive matter soluble in water only, with alkaline carbonate, phosphate, and chloride	0·20
	100·

Human lymph from a lymphatic vessel on the instep of the foot, (Marchand and Colberg):—

Water	96·926
Fibrin	0·520
Albumen	0·434
Osmazome (and loss)	0·312
Fatty matters	0·264
Salts, viz.—Chlorides of sodium and potassium, alkaline carbonate, and lactate; sulphate and phosphate of lime, and oxide of iron	1·544
	100·

The proportion of fibrin has been supposed to increase as the lymph approaches the thoracic duct; thus, from the lumbar lymphatics of a fasting horse, Gmelin obtained 0·25 per cent. of dry coagulum, and from that of the thoracic duct of the same animal, 0·42 per cent. As regards the amount of albumen, Leuret and Lassaigne assign it at 5·7 per cent., but this includes the extractive matter; on the other hand, Berzelius suspects, that the method followed by Marchand and Colberg leads to too low an estimate; but there seems reason to think that, apart from all error, the proportion of this ingredient will be found to vary.

CHYLE.

The chyle of man and mammiferous animals, is an opaque, white fluid, like milk, with a faint odour and saltish taste, slightly alkaline, or altogether neutral in its reaction. It has often a decided red tint, especially when taken from the thoracic duct. This colour, which is heightened by exposure to air, is owing to the presence of blood-corpuscles, and may be explained in the same way as the occasional red colour of lymph.

Like blood and lymph, both of which fluids it greatly resembles in constitution, the chyle consists of a liquid holding small particles in suspension. These particles are, 1. *Chyle corpuscles,* or chyle globules, precisely like the lymph globules and pale blood-corpuscles already described. 2. *Molecules,* of extremely minute, but remarkably uniform size, probably between $\frac{1}{36000}$ and $\frac{1}{24000}$ of an inch in diameter. These abound in the fluid, and form an opaque white molecular matter diffused in it, which Mr. Gulliver has named the *molecular base* of the chyle. The addition of ether instantly dissolves this matter, and renders the chyle nearly, but not quite, transparent; whence it may be inferred, that the molecules are minute particles of fatty matter, and probably the chief cause of the opacity and whiteness of the chyle. They exhibit the usual tremulous movements common to the molecules of many other substances. 3. *Oil globules;* these are of various sizes,

but much larger than the molecules above described, and are often found in the chyle in considerable numbers. 4. *Minute spherules* (Gulliver), from $\frac{1}{24000}$ to $\frac{1}{8000}$ of an inch in diameter; probably of an albuminous nature, and distinguished from the fatty molecules by their varying magnitude and their insolubility in ether.

The plasma, or liquid part of the chyle, contains fibrin, so that the chyle coagulates on being drawn from the vessels, and nearly all the chyle corpuscles, with part of the molecular base, are involved in the clot. The serum which remains, resembles in composition the serum of lymph; the most notable difference between them being, the larger proportion of fatty matter contained in the former.

Subjoined is an analysis, by Dr. Rees, of chyle taken from the lacteals of an ass after the fluid had passed the mesenteric glands, but before it entered the thoracic duct.

Water	90·237
Albuminous matter	3·516
Fibrinous matter	0·370
Extractive matter soluble in water and alcohol	0·332
Extractive matter soluble in water only	1·233
Fatty matter	3·601
Alkaline chloride, sulphate and carbonate, with traces of phosphate, oxide of iron	0·711
	100·

Dr. Rees ascribes the whiteness of the chyle principally to a peculiar substance insoluble in alcohol and in ether, but miscible with water, which he considers analogous to the mucoid matter obtained from the saliva. Others attribute the whiteness chiefly to the fatty ingredients, and this view accords with the fact, that food containing much fat yields a remarkably white and opaque chyle.

The chyle, when taken from the lacteal vessels before they have reached the glands, is generally found to coagulate less firmly than in a more advanced stage of its progress; and it has been observed, that after such feeble coagulation, it will sometimes spontaneously return to the liquid state. In like manner the lymph, before passing the lymphatic glands, occasionally exhibits the same weak coagulation and tendency to subsequent liquefaction; but Mr. Lane justly remarks, that the lymph does not differ in coagulability in the different stages of its progress so decidedly and so generally as has been sometimes alleged; and this observation accords with the statement of Mr. Hewson on the same point.*

Dr. Rees has examined the fluid contained in the thoracic duct of the human subject. It was obtained from the body of a criminal an hour and a half after execution, and, from the small quantity of food taken for some hours before death, it must have consisted principally of lymph. It had a milky hue with a slight tinge of buff; part of it coagulated feebly on cooling: its specific gravity was 1024. Its analysis, compared with that of the chyle of the ass, shows less water, more albumen, less aqueous extractive, and a great deal less fat.†

FORMATION OF THE CORPUSCLES OF THE LYMPH AND CHYLE.

Very little is known concerning this process. No absorbent or open orifices having been discovered in the lymphatics, it can scarcely be supposed, that the lymph globules are introduced into the vessels ready formed, unless it be imagined that the commencing lymphatics are destitute of membranous parietes, and of this there is no evidence. The corpuscles are, therefore, most probably developed as cells within the lymphatic vessels, and there are various modes in which such a production of cells might be conceived to take place. Thus, according to one view, the lymph globules or cells are developed from nuclei in the liquid part of the lymph, which serves as a blastema. In this case the nuclei

* Experimental Inquiries, part ii. p. 105.

† Phil. Trans. 1842.

may be formed by aggregation of matter round nucleoli, which again may be derived as germs from other cells; or, as Henle is disposed to think, two or more fat particles may unite to form a nucleus in the way already described (vol. i. p. 57). Upon another view it may be conceived that the lymph corpuscles are formed on the inner surface of the walls of their containing vessels, as epithelium or mucous corpuscles are produced on their supporting membrane; and that this process may be connected with the absorption of lymph into the vessels, in like manner as secretion into a gland-duct, or other receptacle, is accompanied by the formation and detachment of cells, as will be afterwards explained.

The chyle globules, possessing the same characters as those of the lymph, are most probably formed in the same way. They are found in all parts of the chyliferous system, but most abundantly in chyle obtained from the mesenteric glands;* and this fact readily falls in with the hypothesis, that the corpuscles, or their germs, are thrown off from the inner surface of the vessels.

LYMPHATIC VESSELS.

Under this head we include not only the vessels specially called lymphatics, together with the glands belonging to them, but also those named lacteal or chyliferous, which form part of the same system, and differ in no respect from the former, save that they not only carry lymph like the rest, but are also employed to take up the chyle from the intestines during the process of digestion and convey it into the blood. An introductory outline of the absorbent system has already been given at page 33.

A system of lymphatic vessels is superadded to the sanguiferous in all classes of vertebrated animals, but such is not the case in the invertebrata; in many of these, it is true, the sanguiferous vessels convey a colourless or nearly colourless blood, but no additional class of vessels is provided for conveying lymph or chyle, at least none such has hitherto been detected.

Distribution.—In man and those animals in which they are present, the lymphatic vessels are found in nearly all the textures and organs which receive blood; the exceptions are few, and with the progress of discovery may yet possibly disappear.

Lymphatics have not as yet been traced in the substance of the brain and spinal cord, though they exist in the membranous envelopes of these parts; nor have they been detected within the eyeball, or in the placenta and fœtal envelopes. It is true that some anatomists have succeeded in injecting what they conceive to be plexuses of lymphatic vessels in the cornea of the eye and in the umbilical cord, but it has not been satisfactorily shown that the injection in these cases had really passed into lymphatics. I have distinctly seen lymphatic vessels, distended with their own lymph, on the surface of an eye which had repeatedly suffered from chronic inflammation; but in this case the vessels appeared to be in or immediately beneath the conjunctival membrane.

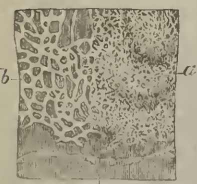
In the different regions of the body, and in the several internal vis-

* Gulliver's Supplement to Gerber's Anatomy, p. 92.

cera, the lymphatics are arranged in a superficial and a deep set. The former run underneath the skin or under the membranous coats immediately enveloping the organs in which they are found; the latter usually accompany the deep-seated blood-vessels. The principal lymphatic vessels of a part exceed the veins in number, but fall short of them in size; they also anastomose or intercommunicate much more frequently than the veins alongside of which they run.

Origin.—This may be either superficial or deep; that is, the lymphatics may arise immediately underneath free surfaces, both external and internal, as for example those of the skin and mucous membranes, or deeply in the substance of organs.

Fig. 264.



Lymphatic vessels of the skin of the breast injected,—after Breschet.—*a*, superficial, and *b*, deeper plexus. *c*. A lymphatic vessel, which proceeded to the axillary glands.

In the *superficial* mode of origin, the lymphatics most generally arise in form of networks or plexuses out of which single vessels emerge at various points and proceed directly to lymphatic glands or to join larger lymphatic trunks. These plexuses of origin for the most part consist of several strata, becoming finer as they approach the surface, in respect both of the calibre of the vessels and the closeness of their reticulation. This is shown in the adjoining figure (264), which is meant to represent the lymphatic plexuses of the skin. But even the most superficial and finest network is composed of vessels which are larger than the sanguiferous capillaries. They do not open on the surface, as was at one time supposed, and the fluids which they imbibe must pass into them by transudation.

In some situations the plexuses of origin have much the appearance of strata of intercommunicating cells, and accordingly the lymphatics have been sometimes described as arising from small cellular cavities. A characteristic example of the appearance referred to is afforded by the intestine of the turtle, after its lymphatics have been injected with mercury; these vessels are then seen to emerge from what has all the appearance of a dense stratum of small rounded cells filled with mercury and lying beneath the surface of the mucous coat. This appearance is, however, to be regarded as in reality produced by the short distended branches of a very close lymphatic network, and transitions are accordingly met with between this and the more usual and regular forms.

But the plexiform mode of origin, though perhaps the most common, is not universal. According to recent observations by Kölliker, the cutaneous lymphatics in the tail of batrachian larvæ branch out in an arborescent manner, and do not unite into a network; their ultimate branches, or, to speak, perhaps, more properly, their commencing radicles, have free but closed ends, not dilated, but running out into fine points. Again, the origin of the lacteals in the intestinal villi is by many held to be peculiar. It was supposed by some that they began by open mouths on the surface of the villi. Lieberkühn conceived that there was a single opening on the summit of each villus leading to a cellular cavity within, which he named "ampulla," and from which a lacteal vessel proceeded. Cruikshank, from what he saw in examining the human villi when they were distended with chyle, was led to believe that each of these processes had on its surface several orifices of commencing lacteals. Others, denying the reality of these apparent openings, still differ in opinion as to the arrangement of the lacteal vessels within the villi. Some, following the opinion of Mascagni and Meckel, describe the commencing lacteals of a villus as arranged in a plexus

like its blood-vessels; and this view, which is also supported by recent observations of E. H. Weber, appears to be the most probable. Krause describes and figures a lacteal taking its rise in a villus by several smaller branches, of which some appear to commence by a free extremity, and others join in a plexus. Henle, on the other hand, found in each of the villi only a single lacteal branch with a blind dilated extremity, and this view, or one substantially the same, is supported by Herbst.*

When lymphatics arise deeply, their origin is hidden from view, and the precise mode in which it takes place is not known. There is, however, no good ground for supposing that it differs in any essential point from what is observed in the more obvious cases already referred to.

It has been sometimes maintained that the lymphatics of glandular organs communicate at their origin with the ducts; but, although it is no uncommon thing for matters artificially injected into the ducts of glands, as, for instance, those of the liver and testicle, to pass into the lymphatics, a careful examination of such cases leads to the conclusion that the injected material does not find its way from the ducts into the lymphatics by any naturally existing communication, but by accidental rupture of contiguous branches of the two classes of vessels. It seems, probable, also, that the communications often held to exist between the commencing lymphatics, both superficial and deep, and capillary blood-vessels, have no better foundation, and that the passage of injection here also relied on as evidence, is to be accounted for in the same way. A fact mentioned by Kölliker throws light on these alleged communications with sanguiferous capillaries. In investigating the lymphatics of the tadpole's tail with the microscope, that observer not unfrequently noticed that blood corpuscles got into the lymphatics from the small blood-vessels, and he was able to recognise in the living animal the communications by which they passed. At first he looked on these communications as natural, but, after repeated and careful investigations, he satisfied himself that they were produced accidentally by contusions or some other injuries inflicted on the parts.

Structure.—The lymphatic vessels have much thinner coats than the arteries or veins, so thin and transparent indeed that the contained fluid can be readily seen through them. Kölliker describes the fine lymphatics which he saw in the tail of batrachian larvæ as consisting of a simple homogeneous membrane like that of the sanguiferous capillaries, only still more delicate, and like that also presenting nucleiform corpuscles, which were enveloped in groups of fine granules. The vessels were jagged or serrated along both sides with sinuosities and pointed denticulations. According to Henlé, the commencing lacteals in the intestinal villi consist also of a simple membrane with elongated nucleiform corpuscles lying in a longitudinal direction.

The medium-sized and larger lymphatics, as well as the thoracic duct, are admitted by all anatomists to have at least two coats, and some assign three, besides an epithelium on the inner surface. Mr. Lane describes three, namely, an internal, which is lined by the epithelium, a middle or fibrous, and an external, analogous to the external or cellular coat of the blood-vessels. The *inner* tunic is thin and transparent, also extensible and elastic, but less so than the other coats, for it is the first to give way when the vessel is unduly distended; its internal surface is covered with a simple layer of scaly

* Das Lymphgefässsystem und seine Verrichtungen. Götting. 1844.

epithelium, as in the blood-vessels. The *middle* or fibrous coat, is very extensible and elastic. It consists, according to Mr. Lane, of longitudinal fibres, having the anatomical characters of the plain, involuntary muscular fibres, freely mixed with fibres of cellular tissue. Herbst describes two layers of plain muscular fibres in the middle tunic, but Mr. Lane states, that, although a few may be distinguished next to the inner coat, taking a transverse, and others an oblique direction, the great majority run longitudinally. The *external* or cellular coat resembles that of the blood-vessels, like which it possesses considerable extensibility and elasticity, and is composed of interlaced fasciculi of areolar tissue, mixed with some elastic fibres.

The lymphatics receive vasa vasorum, which ramify in their outer and middle coats: nerves distributed to them have not yet been discovered, although their probable existence has been inferred on physiological grounds.

Vital properties.—That the lymphatics are endowed with vital contractility is shown by the effect of mechanical irritation applied to the thoracic duct, as well as by the general shrinking and emptying of the lacteal and lymphatic vessels on their exposure to the contact of cold air, in the bodies of animals opened immediately after death.

Valves.—The lymphatic and lacteal vessels are furnished with valves serving the same office as those of the veins, and for the most part constructed after the same fashion. They generally consist of two semilunar folds arranged in the same way as in the valves of veins already described, but deviations from the usual structure here and there occur. Thus Mr. Kane has observed some valves in which the planes of the semilunar flaps were directed not obliquely but transversely across the vessel; an arrangement calculated to impede the flow of fluid in both directions, but not completely to intercept it in either. In others, described by the same authority, the two folds, placed transversely as before, were coalesced at one end, so as to represent a transverse septum with an incomplete transverse slit. In a third variety, he found the valve formed of a circular fold corresponding with a constriction outside, and probably containing circular contractile fibres capable of completely closing the tube.

Valves are not present in all lymphatics, but where they exist they follow one another at much shorter intervals than those of the veins, and give to the lymphatics, when much distended, a beaded or jointed appearance. Valves are placed at the entrance of the lymphatic trunks into the great veins of the neck. They are wanting in the reticularly arranged vessels which compose the plexuses of origin already spoken of; so that mercury injected into one of these vessels runs in all directions so as to fill a greater or less extent of the plexus, and passes along the separate vessels which issue from it.

The lymphatics of fish and naked amphibia are, generally speaking, destitute of valves, and may therefore be injected from the trunks; in the turtle a few valves are seen on the larger lacteals which pass along the mesentery, but none on those upon the coats of the intestine; and valves are much less numerous in the lymphatics and lacteals of birds than in those of mammiferous animals.

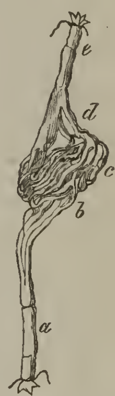
Absorbent or *lymphatic glands*, named also *conglobate glands*, and by modern French writers, *lymphatic ganglions*, are small solid bodies placed in the course of the lymphatics and lacteals, through which the contents of these vessels have to pass in their progress towards the thoracic or the right lymphatic duct. These bodies are collected in numbers along the course of the great vessels of the neck, also in the thorax and abdomen, especially in the mesentery and alongside the aorta, vena cava inferior and iliac vessels. A few, usually of small size, are found on the external parts of the head, and considerable groups are situated in the axilla and groin. Some three or four lie on the popliteal vessels, and usually one is placed a little below the knee, but none farther down. In the arm they are found as low as the elbow-joint.

A lymphatic vessel may pass through two, three, or even more lymphatic glands in its course, whilst, on the other hand, there are lymphatics which reach the thoracic duct without encountering any gland in their way.

The size of these bodies is very various, some being not much bigger than a hempseed, and others as large or larger than an almond or a kidney-bean. In shape too they present differences, but most of them are round or oval.

A lymphatic gland essentially consists of a network of finely divided lymphatic vessels, on and between which capillary blood-vessels are ramified, the whole being gathered up and compacted into a comparatively dense mass by cellular tissue, which at the surface of the gland forms for it an inclosing capsule. The lymphatics or lacteals which enter a gland are named inferent or afferent vessels (*vasa inferentia* seu *afferentia*) (fig. 265, *a*, *b*) and those which issue from it, efferent vessels (*vasa efferentia*,) (*d*, *e*). The afferent vessels, on approaching a gland, divide into many small branches (*b*), which enter the gland and by their further ramifications, which are more or less involved or tortuous, form within it an intricate plexus (*c*) ; from this plexus the efferent vessels proceed in form of small branches (*d*), which issue from the gland, and at a little distance beyond it unite in one or more trunks (*e*), usually larger in size but fewer in number than those of the afferent vessels. The afferent and efferent vessels are therefore continuous with each other within the gland, and the cellular cavities described by some anatomists as intervening between them and serving as the medium of their communication, appear to be nothing more than partial dilatations of some branches of the common connecting plexus.

Fig. 265.



A lymphatic gland injected with mercury and dried,—after Hewson.—*a b* inferent, *d e* efferent vessels, communicating with *c*, plexus of lymphatics within the gland.

The plexiform branches of lymphatics within the glands must evidently be collectively more capacious than the afferent or efferent vessels with which they

are continuous, and hence the lymph or chyle must move more slowly through them, and while thus detained or delayed in the gland, it is brought into close relation with the blood of the numerous capillaries distributed on the lymphatic plexus, and is thus placed in the most favourable condition for receiving matters from that fluid, or for yielding up something to the sanguiferous system. The transmission of matters from the blood-vessels to the lymphatics within the glands, or the mutual interchange of part of their contents, if such there be, would seem therefore to take place not by means of inosculation of the vessels, but by transudation through their permeable coats, as in the case of the air and blood in the lungs.

In a gland a large number of plexiform lymphatic vessels, presenting a great extent of surface for the contact of lymph and for the distribution of sanguiferous capillaries, are collected into a compact mass of small compass; but in fishes and reptiles, in which there are no lymphatic glands, and in birds, in which there are very few, the purpose served by them is accomplished by means of lymphatic networks occurring in various parts of the body, especially along the course of the larger arteries.* In this lax or expanded form of lymphatic gland, as it might be considered, capillary blood-vessels are distributed on the lymphatic plexus, but the different elements are not compacted into a solid mass.

It is known that the lymph and chyle contain a greater proportion of fibrin, and are consequently more perfectly coagulable, after passing the glands, and it is also observed that the proper corpuscles of the chyle and lymph are most abundant in that which is obtained by puncturing the small branches of lacteals or lymphatics on the glands. From this latter circumstance, it has been supposed that these corpuscles, though probably also generated elsewhere in the lymphatic and lacteal vessels, are principally produced in the glands, and this view is also in harmony with the observations of Mr. Goodsir respecting the modifications of structure which the absorbent vessels present within these organs. According to that anatomist, the lymphatics within the gland lay aside all but their internal coat and epithelium, and the latter, in place of forming a thin lining of flat transparent scales, as in the extra-glandular lymphatics, acquires an opaque granular aspect, and is converted into a thick irregular layer of spherical nucleated corpuscles, measuring on an average $\frac{1}{3000}$th of an inch in diameter, and suggesting the idea of lymph or chyle corpuscles generated on the internal membrane after the usual manner of epithelium cells, and about to be thrown off into the cavity of the vessel. Mr. Goodsir adds, that this layer is thickest in those lymphatics which are situated towards the centre of the gland, and becomes gradually thinner towards the afferent and efferent vessels, when it passes continuously into the ordinary epithelium.

Termination.—The absorbent system discharges its contents into the veins at two points, namely, at the junction of the subclavian and internal jugular veins of the left side by the thoracic duct, and in the corresponding part of the veins of the right side by the right lymphatic trunk. The openings, as already remarked, are guarded by valves. It sometimes happens that the thoracic duct divides, near its termination, into two or three short branches, which open separately, but near each other; more rarely, a branch opens into the vena azygos, indeed the main vessel has been seen terminating in that vein. Again, it is not

* Not only do the lymphatics of many oviparous vertebrata surround the larger arteries in form of close plexuses, but, according to Rusconi, the aorta and mesenteric arteries of the frog and salamander are actually inclosed in wide lymphatic vessels. It has been presumed that in instances such as the last mentioned, the artery is separated from the lymph by a reflection of the coat of the containing lymphatic vessel, but Rusconi maintains that such is not invariably the case. See his work entitled Riflessioni sopra il Systema Linfatico dei Rettili, Pavia, 1845, in which will also be found, besides many interesting observations on the lymphatic system of reptiles, an account of his approved method of injecting these vessels.

uncommon for larger branches which usually join the thoracic duct, to open independently in the vicinity of the main termination; and this is more apt to happen with the branches which usually unite to form the right lymphatic trunk. By such variations the terminations in the great veins are multiplied, but still they are confined in man to the region of the neck; in birds, reptiles, and fish, on the other hand, communications take place between the lymphatics of the pelvis, posterior extremities and tail, with the sciatic or other considerable veins of the abdomen or pelvis.

The alleged terminations of lymphatics in various veins of the abdomen, described by Lippi as occurring in man and mammalia, have not been met with by those who have since been most engaged in the prosecution of this department of anatomical research, and accordingly, his observations have generally been either rejected as erroneous, or held to refer to deviations from the normal condition.* But, while such (extra-glandular) terminations in other veins than those of the neck have not been generally admitted, several anatomists of much authority have maintained that the lacteals and lymphatics open naturally into veins within the lymphatic glands. This latter opinion, which has been strenuously advocated by Fohmann in particular, is based on a fact well known to every one conversant with the injection of the vessels in question, namely, that the quicksilver usually employed for that purpose, when it has entered a gland by the inferent lymphatics, is apt to pass into branches of veins within the gland and thus find its way into the large venous trunks in the neighbourhood, in place of issuing by the efferent lymphatic vessels. But, although it, of course, cannot be doubted that, in such cases, the mercury gets from the lymphatics into the veins, no one has yet been able to perceive the precise mode in which the transmission takes place, and, looking to the circumstances in which it chiefly occurs, it seems to be more probably owing to rupture of contiguous lymphatics and veins within the glands, than to a natural communication between the two classes of vessels in that situation.

Lymphatic hearts.—Some years ago, Müller and Panizza, nearly about the same time, but independently of each other, discovered that the lymphatic system of reptiles is furnished, at its principal terminations in the venous system, with pulsatile muscular sacs, which serve to discharge the lymph into the veins. These organs, which are named lymph-hearts, have now been found in all the different orders of reptiles. In frogs and toads two pairs have been discovered, a posterior pair, situated in the sciatic region, which pour their lymph into a branch of the sciatic or of some other neighbouring vein, and an anterior more deeply seated pair, placed over the transverse process of the third vertebra, and opening into a branch of the jugular vein. The parietes of these sacs are thin and transparent, but contain muscular fibres of the striated kind, disposed spirally, and decussating in different layers, as in the blood-heart. In their pulsations they are quite independent of the latter organ, and are not even synchronous with each other. In salamanders, lizards, serpents, tortoises, and turtles, only a posterior pair have been discovered, which, however, agree, in all essential points, with those of the frog.† In the goose, and in other species of birds belonging to dif-

* In a recent communication inserted in Müller's Archiv. for 1848, p. 173, Dr. Nuhn, of Heidelberg, maintains the regular existence of these abdominal terminations, and refers to three instances which he met with himself. In two of these, the lymphatics opened into the renal veins, and in the other into the vena cava.

† Rusconi, who has lately given a description and figure of the posterior lymph-hearts of the frog (Op. cit. p. 65; Tav. iv. fig. 7), suggests (and the suggestion is not peculiar to him) that the remarkable pulsating sac connected with the caudal vein of the eel, which was discovered by Dr. Marshall Hall, and the sinuses opening into other veins, in certain fishes, since pointed out by Hyrtl, are probably of the same nature as the lymph-hearts of reptiles.

ferent orders, Panizza discovered a pair of lymph-sacs opening into the sacral veins,* and Stannius has since found that these sacs have striated muscular fibres in their parietes; but, although this observer, in some cases, exposed them in the living bird, he was not able to discover any pulsation or spontaneous movement in them.†

Development of lymphatic vessels.—Kölliker states that he has observed the formation of lymphatics from ramified cells in the tails of young salamander-larvæ. He states that the process takes place nearly in the same manner as in the case of the sanguiferous capillaries already described; the only notable difference being that, whilst the growing lymphatics join the ramified cells, and thus extend themselves, their branches very rarely anastomose or become connected by communicating arches. New-formed lymphatics have been injected in adhesions between inflamed serous membranes.

THE ABSORBENTS.

The absorbent vessels consist of the *lacteals*, which, after digestion, convey the chyle from the alimentary canal to the thoracic duct, and of the *lymphatics*, which take up the lymph from all the other parts of the body, and return it through the thoracic duct, or directly, into the venous system. Both these vessels are connected in their course with *lacteal* or *lymphatic* glands.

The general anatomy of the absorbents having been detailed, their course and position have now to be described.

The lacteals all terminate in the *thoracic duct*, a large common trunk, which also receives the lymphatics from both the lower limbs, from the cavity of the abdomen and its viscera, (except the right lobe of the liver,) from the walls of the abdomen, and from the left side of the thorax, from the left lung, the left side of the heart, and left side of the diaphragm, from the left upper limb, and from the corresponding side of the head and neck. But the lymphatic vessels which arise from the right upper limb, the right side of the head and neck, from the right lung, and from the corresponding half of the liver and diaphragm, terminate by a short trunk, which enters the place of junction of the right subclavian and internal jugular veins. This vessel may be called the *right lymphatic duct;* it is commonly named the right thoracic duct, though no part of it lies within the thorax. Indeed, the duct of the left side is not exclusively thoracic; for its commencement is in the abdomen, and its termination in the neck. The thoracic duct, the right lymphatic duct, and all the principal absorbent vessels, are provided with numerous valves, owing to the constrictions opposite which, these vessels have a varicose appearance.

* Osservazioni antropo-zootomico-fisiologiche. Pavia, 1830, pp. 65 and 67.
† Müller's Archiv., 1843, p. 449.

The *lacteals* (vasa lactea, chylifera).—These vessels commence in the coats of the intestines, by a very close plexus, and extend to the thoracic duct, in which they all terminate: they are derived in far larger numbers from the small than from the large intestine, so that they abound in the mesentery, and particularly in that part of it which corresponds with the jejunum and duodenum. Two sets of these absorbing vessels are found along the tube of the intestine, having different positions and directions. Some of them, for example those nearer to the outer surface of the intestine, run longitudinally in the course of the canal, lying beneath its peritoneal coat; whilst others, placed more deeply between the muscular and mucous coats, course transversely around the intestine, and are directed thence with the arteries and veins, along the mesentery, enclosed within the folds of the peritoneum. It was at one time supposed that the more superficial absorbents of the intestine were lymphatics, and that the others only were lacteals; but such a distinction cannot be made between them, and they freely communicate and anastomose together. "The lacteals (says Cruikshank) absorb chyle when it is presented to them; and at other times they absorb other fluids."* The lacteals, having entered the mesentery, take the course of the blood-vessels, and pass through the numerous lymphatic glands (mesenteric glands) which exist within these peritoneal folds. The *mesenteric glands* vary in number from a hundred and thirty to a hundred and fifty; and in the healthy state are seldom larger than an almond. They are most numerous in that part of the mesentery which corresponds with the jejunum; and they seldom occur nearer to the attached border of the intestine than two inches. They are the seat of unhealthy deposits in mesenteric disease. Small glands are also disseminated irregularly between the folds of the peritoneum connected with the large intestine, but they are not numerous in that situation.

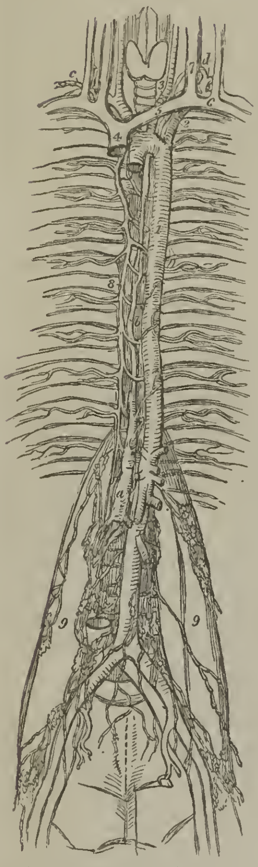
Having passed through these glands, the lacteals gradually unite as they approach the attached border of the mesentery, two or three perhaps joining into one; and so they become diminished in number, until at length, near the root of the superior mesenteric artery, only two or three trunks remain, which end in the thoracic duct. Sometimes, however, six or seven of these vessels open separately into the commencement of the duct. In this way, the lacteals from the whole of the small intestine, from the cæcum, and from the ascending and transverse parts of the colon, terminate; those from the descending colon and its sigmoid flexure usually join some of the lumbar lymphatics, or turn upwards and open by a separate trunk into the lower end of the thoracic duct.

To the same point, viz., the lower end of the thoracic duct, may be traced, from below upwards, the lymphatic vessels from the lower limbs; so that the thoracic duct may be said to commence at the common point of junction of these lymphatics with the trunks of the lacteal vessels.

* Anatomy of the Absorbing Vessels, p. 161.

THORACIC DUCT.

Fig. 266.



The aorta is marked 1, the left subclavian artery, 2, the left carotid 3, the upper cava 4, the left innominate vein 5, the left subclavian vein 6, the left internal jugular vein 7, the azygos vein 8, the psoas muscles 9, 9. *a*, *b*, *b*, is the thoracic duct; *a*, the receptaculum chyli; *b*, the trunk of the vessel; *d*, its termination in the neck. *c* is the right lymphatic duct. N.B. The receptaculum chyli, which in this place is placed on the right side of the aorta, is most commonly to its left side, and behind it.

The *thoracic duct* [ductus thoracicus], fig. 266, *b*, is from eighteen to twenty inches long in the adult, and extends usually from the second lumbar vertebra to the root of the neck. Its commencement, however, is often as low as the third lumbar vertebra; and in some cases as high as the first lumbar, or even upon the last dorsal vertebra. Here there is usually a dilatation of the duct, of variable size, which is called *chyli receptaculum* (Pecquet), fig. 266, *a*. The thoracic duct, at first, lies to the left side of and behind the aorta, and is about three lines in diameter; but as it ascends it passes to the right side of that vessel, getting into contact with the right crus of the diaphragm, and so reaches the thorax, where it is placed at first upon the front of the dorsal vertebræ, between the aorta, 1, and the azygos vein, 8, the latter being to its right side. It ascends, gradually inclining to the left and at the same time diminishing in size, until it reaches the third dorsal vertebra, where, after passing behind the arch of the aorta, it comes into contact with the œsophagus, lying between its left side and the pleura. Continuing its course, it ascends into the neck, supported by the longus colli muscle, until it arrives on a level with the upper border of the seventh cervical vertebra, where it changes its direction and turns forwards, at the same time arching downwards and inwards so as to describe a curve, *d*, and then terminates on the outer side of the internal jugular vein, 7, in the angle formed by the union of that vein with the subclavian, 6. The diminution in the size of the duct as it ascends has been already noticed; at the fifth dorsal vertebra it is often only two lines in diameter, but above this point it enlarges again. It is generally waving and tortuous in its course, and is constricted at intervals or varicose in its appearance. The thoracic duct is not always a single trunk throughout its whole extent: it frequently divides opposite the seventh or eighth dorsal vertebra into two trunks, which soon join again: sometimes in its course it

separates into three divisions, which afterwards unite, and enclose between them spaces or islets. Cruikshank in one case found the duct double in its entire length ; " in another triple, or nearly so." In the neck, the thoracic duct often divides into two or three branches, which in some instances terminate separately in the great veins, but in other cases unite first into a common trunk.

The thoracic duct has numerous double valves at intervals throughout its whole course, which are placed opposite to the constricted parts of the vessel. They are more numerous in the upper part of the duct. At the termination of the duct in the veins there are two valves, so placed as to allow the contents of the duct freely to pass into the veins, but which would effectually prevent the regurgitation of either chyle or blood back into the duct.

THE RIGHT LYMPHATIC DUCT.

The *right lymphatic duct* [ductus thoracicus dexter s. minor], fig. 266, *c*, is a short vessel, about a line or line and a half in diameter, and about three quarters of an inch in length, which receives the lymph from the absorbents of the right upper limb, and right side of the head and chest. It enters obliquely into the receding angle formed by the union of the right subclavian and internal jugular veins, where its orifice is guarded by two valves.

The course of those lymphatic vessels which pour their contents into the thoracic duct will be now described, beginning with those of the lower limbs.

LYMPHATICS OF THE LOWER LIMB.

The lymphatics of the lower limb are arranged in a superficial and a deep series.

The *superficial lymphatics*, [figs. 267, 268,] placed between the integument and fascia of the limb, are arranged into two sets, of which one accompanies the long saphenous, whilst the other follows the course of the short saphenous vein. The vessels composing the first or *internal* set commence on the dorsum and inner side of the foot, and, passing partly in front and in part behind the inner ankle, ascend along the inner side of the knee and front of the thigh, and terminate in the superficial inguinal glands. In their course these vessels are joined by numerous branches proceeding from the integuments of the leg and the thigh. The lymphatics which constitute the second or *external* division of the subcutaneous series, are much less numerous than those just described. Commencing upon the outer margin of the foot, they pass behind the outer malleolus, and ascend along the back part of the leg ; here they perforate the fascia, and proceed between the heads of the gastrocnemius muscle to terminate in the lymphatic glands of the popliteal space. This course corresponds with that of the short saphenous vein, which these lymphatics accompany.

[Fig. 267.

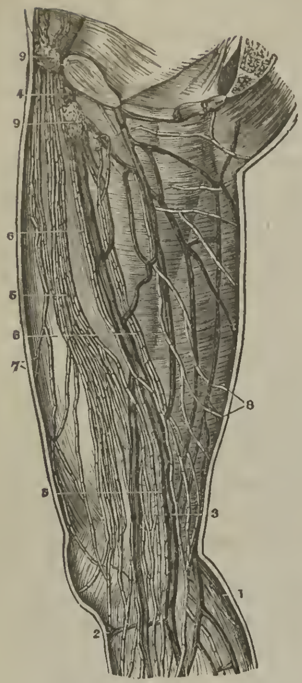


Fig. 268.

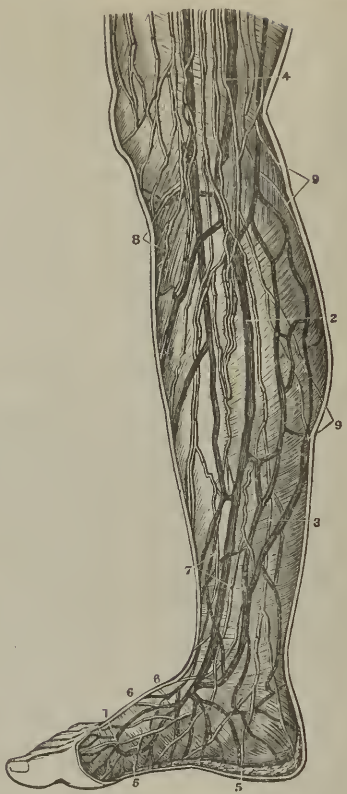


Fig. 267. A view of the superficial lymphatics of the thigh. 1. The external or saphena minor vein. 2. The venous anastomosis below the patella. 3. Femoral portion of the saphena major. 4. Point where it enters the femoral vein. 5. The great chain of superficial lymphatics on the inner side of the thigh. 6, 6. A chain of three or four parallel trunks, which accompany the saphena-major vein. 7. Branches from the front of the thigh. 8. Branches from the posterior part. 9, 9. The inguinal glands into which the superficial lymphatics of the lower extremity enter.

Fig. 268. The superficial lymphatics of the inner side of the foot and leg. 1. The venous anastomosis on the phalangeal ends of the metatarsal bones. 2. The saphena magna vein. 3. Lymphatics on the back of the leg. 4. The same vessels on the lower part of the thigh. 5, 5. Lymphatics coming from the sole of the foot. 6, 6. Lymphatics from the dorsal surface of the foot. 7. The lymphatics which accompany the saphena veiu. 8. Branches of lymphatics from the front and outside of the leg. 9. Branches from the posterior and internal side of the calf of the leg.—S. & H.]

The *deep-seated lymphatics* [figs. 269, 270] of the lower limb, associated in their whole course with the deep blood-vessels, require but a brief description. In the leg, they consist of three divisions, namely, anterior tibial, posterior tibial, and peroneal. Neither these nor the superficial absorbents pass through any lymphatic gland in the leg, unless it be those lymphatics which accompany the anterior tibial artery, for a small gland is sometimes found on the front of the interosseous ligament, above the middle of the leg. The several sets of deep lym-

[Fig. 269.

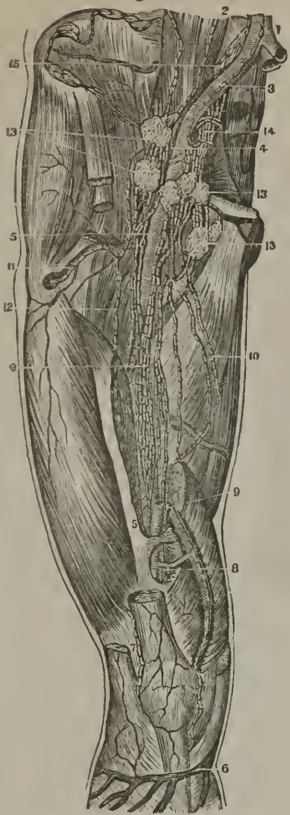


Fig. 270.

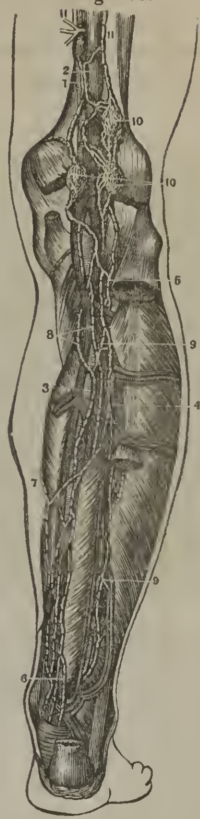


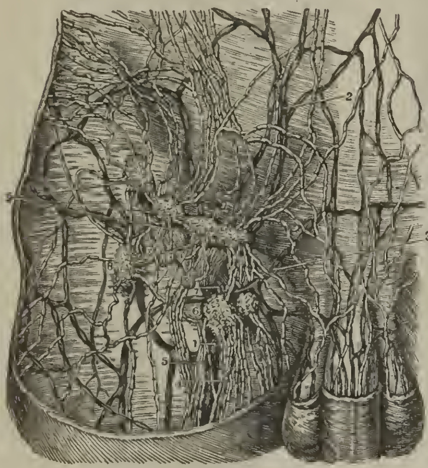
Fig. 269. A front view of the deep-seated lymphatics of the thigh. 1. Lower end of the aorta. 2. Primitive iliac vein. 3, 4. External iliac artery and vein. 5. Femoral artery. 6. Section of the femoral vein. 7. Vena saphena on the leg. 8. Lymphatics near the knee. 9. Lymphatics accompanying the femoral vessels. 10. Deep lymphatics going from the inside of the thigh to the glands in the groin. 11. Lymphatics of the external circumflex vessels. 12. Lymphatics on the outer side of the femoral vessels. 13. A lymphatic gland always found outside of the vessels. 14. A collection of vessels and glands from the internal iliac vessels. 15. The lymphatics of the primitive iliac vessels.

Fig. 270. The deep-seated lymphatic vessels and glands on the back of the leg. 1. Popliteal artery. 2. Popliteal vein. 3. Posterior tibial vessels; the artery is between its two veins. 4. Peroneal artery and veins. 5. Lymphatic vessels from the front of the leg, coming through the opening in the interosseous ligament. 6. Deep-seated lymphatic vessels which arise in the sole of the foot and accompany the blood-vessels. 7. Anastomosis of the superficial and deep-seated lymphatics. 8, 9. Uniting branches of posterior tibial lymphatics. 10, 10. Popliteal glands which receive the deep lymphatics of the leg and foot. 11, 11. Efferent popliteal trunks which accompany the blood-vessels to the femoral glands.—S. & H.]

phatics in the leg ascend with the blood-vessels, and enter the lymphatic glands situated in the popliteal space. These (the *popliteal lymphatic glands*) are usually very small, and four or five in number; they surround the popliteal vessels, and are embedded in a quantity of loose fat. The popliteal glands receive from below, the deep lymphatics of the leg and those which accompany the short saphenous vein; and from them proceed efferent vessels, which ascend with the femoral artery to the groin.

The lymphatic glands of the groin, *inguinal glands*, like the lymphatic vessels of that part, are, from their relative position, divisible into a superficial and a deep set; the former being placed immediately under the integument, the latter under the fascia lata. The *superficial glands* [fig. 271,] are larger than the others; their number varies much, but may be stated to average about eight or ten; they are disposed irregularly about Poupart's ligament and the saphenous opening of the fascia; a few sometimes extend for two or three inches downwards on the saphenous vein. The *deep-seated glands* [fig. 269,] are placed behind the others, around the femoral artery and vein.

[Fig. 271.



The lymphatic vessels and glands of the groin of the right side. 1. Saphena magna vein. 2. Veins on the surface of the abdomen. 3. External pudic vein. 4. The lymphatic vessels collected in fasciculi and accompanying the saphena vein on its inner side. 5. The external trunks of the same set of vessels. 6. The lymphatic gland which receives all these vessels. It is placed on the termination of the saphena vein. 7. The efferent trunks from this gland; they become deep-seated and accompany the femoral artery. 8. One of the more external lymphatic glands of the groin. 9. A chain of four or five inguinal glands, which receive the lymphatics from the genitals, abdomen, and external portion of the thigh.—S. & H.]

Besides the lymphatics of the lower limb, the inguinal glands are joined by the superficial absorbent vessels from the perinæum and the external generative organs, as will be presently noticed, and by those from the lower part of the abdominal walls, and the integuments covering the outer side of the pelvis. The deep lymphatics, derived from the muscles on the pelvis, and many proceeding from the adductor muscles of the thigh, in company with the gluteal, sciatic, and obturator arteries, enter the cavity of the pelvis with those vessels, and pass through a series of glands situated in the neighbourhood of the internal and common iliac arteries. The efferent vessels of the superficial inguinal glands perforate the fascia, come into connexion with those situated deeply, pass into the abdomen by the side of the blood-vessels, and terminate in a chain of lymphatics lying along the external iliac artery, and ending in the lumbar glands.

LYMPHATICS OF THE ABDOMEN AND PELVIS.

Superficial lymphatics of the abdomen and pelvis [fig. 271]. The lymphatic vessels of the *walls* of the abdomen and pelvis consist of several series, which pursue different directions, but are all associated with the blood-vessels of different parts. A superficial series, derived from the integument of the lower part of the abdomen (from the umbilicus downwards), descends towards the superficial inguinal glands; whilst a deep-seated series in the same situation is also directed down-

wards, and ends in the glands situated on the external iliac artery: these two sets follow respectively the superficial and deep epigastric blood-vessels. Other lymphatics, proceeding from the side and back part of the walls of the abdomen, perforate the fibres of the muscles; a small number of them then wind round the crest of the ilium, passing in their course through one or two small glands, and proceed along Poupart's ligament with the circumflex iliac artery, to terminate in the glands upon the external iliac artery; whilst the greater number are directed backwards with the ilio-lumbar and lumbar arteries, and, being joined by the lymphatics from the muscles and integument of the back, pass behind the psoas muscle to the vertebral column, where they enter the glands surrounding the aorta and lower vena cava.

The *superficial lymphatics of the pelvis*, as already described, are directed for the most part towards the inguinal glands.

The *superficial lymphatics of the penis* usually form three vessels, two being placed at the sides, and the other on the dorsum of the organ. Commencing in the prepuce, they pass backwards, unite on the dorsum penis, and, again subdividing, send branches on each side to the inguinal glands.

The *lymphatics of the scrotum*, with those from the integuments of the perineum, may be associated together; for all, guided, as it were, by the superficial pudic vessels, enter the inguinal lymphatic glands. The *deep-seated* lymphatics of the penis accompany the internal pudic vessels, and end in the glands on the internal iliac artery.—The lymphatics of the external generative organs in the female present a similar disposition to that here described in the male.

Deep lymphatics of the pelvis and abdomen—lymphatics of the viscera.—The course of these deep lymphatic vessels, as in other parts, is indicated by that of the principal blood-vessels.

The *lymphatics of the bladder*, taking rise from the entire surface of that organ, enter the glands placed about the internal iliac artery: with these are associated the lymphatics of the prostate gland and of the vesiculæ seminales.

The *lymphatics of the rectum* are frequently of considerable size: immediately after leaving the intestine, some of them pass through small glands which lie contiguous to it; finally, they enter the lymphatic glands situated in the hollow of the sacrum, or those higher up in the loins.

In the unimpregnated state of the *uterus*, its lymphatics are small, but during the period of gestation they are considerably enlarged. Issuing from the entire substance of the organ, the greater number descend, together with those of the vagina, and pass backwards to enter the glands upon the internal iliac artery; thus pursuing the course of the principal uterine blood-vessels. Others, proceeding from the upper end of the uterus, run outwards in the folds of peritoneum which constitute its broad ligaments, and join the lymphatics derived from the ovaries and Fallopian tubes. The conjoined vessels then ascend with the ovarian arteries, near the origin of which they terminate in the lymphatic vessels and glands placed on the aorta and vena cava.

The *lymphatics of the testicle* commence in the substance of the gland, and upon the surface of the tunica vaginalis. Collected into

several large trunks, they ascend with the other constituents of the spermatic cord, pass through the inguinal canal, and accompany the spermatic vessels in the abdomen to enter the lumbar lymphatic glands.

The lymphatics of the kidney.—Those placed upon the surface of the organ are comparatively small; they unite at the hilus of the kidney with other lymphatics from the substance of the gland, and then pass inwards to the lumbar lymphatic glands. The lymphatics of the *supra-renal capsules* unite with those of the kidney. The lymphatic vessels of the *ureter* are numerous; they communicate with those of the kidney and the bladder, and for the most part terminate with the former.

The *lymphatics of the stomach* are placed, some beneath the peritoneal coat, and others between the muscular and mucous coats. Following the direction of the blood-vessels, they become arranged into three sets. One set accompanies the coronary vessels, and receiving, as it runs from left to right, branches from both surfaces of the organ, turns backwards near the pylorus, to join some of the larger trunks. Another series of lymphatics, from the left end of the stomach, follow the vasa brevia, and unite with the lymphatics of the spleen; whilst the third set, guided by the right gastro-epiploic vessels, incline from left to right along the great curvature of the stomach, from which they pass backwards, and at the root of the mesentery terminate in one of the principal *lacteal* vessels.

The *lymphatics of the spleen* are placed, some immediately under its peritoneal covering, others in the substance of the organ. Both sets converge to the inner side of the spleen, come into contact with the blood-vessels, and, accompanying these, pass through a series of small glands, and terminate in the lymphatics of the digestive organs.

Lymphatics emerge from the *pancreas* at different points, and join those derived from the spleen.

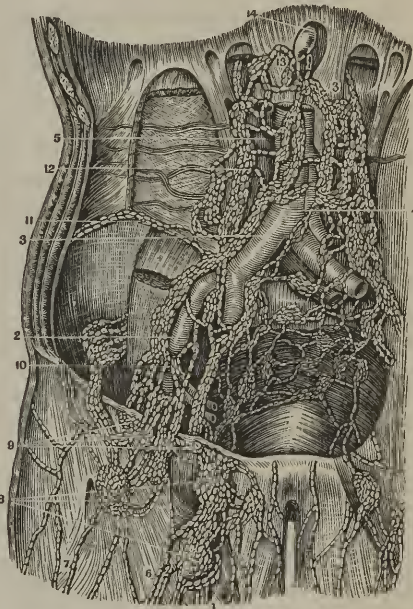
The *lymphatics of the liver* are divisible into three principal sets, accordingly as they are placed upon its upper or its under surface, or are spread through its substance with the blood-vessels.

. The lymphatic vessels scattered upon the *upper* surface of the liver incline towards particular points, and so become distinguishable into groups, of which four are ordinarily enumerated. Thus, from the middle of this surface of the liver, five or six branches run towards the falciform ligament, on which, directed forwards, they unite to form a large trunk, which passes upwards between the fibres of the diaphragm, behind the ensiform cartilage. Having reached the interpleural space, behind the sternum, they ascend through a chain of lymphatic glands, found upon the internal mammary blood-vessels, and are thus conducted to the root of the neck, generally at the right side, where they terminate in the right lymphatic duct. The second group consists of vessels which incline outwards towards the right lateral ligament, opposite to which they unite into one or two larger lymphatics, which pierce the diaphragm and run forward upon its upper surface to join the preceding set of vessels behind the sternum. In some cases, however, instead of passing into the thorax, they turn inwards on reaching the back part of the liver, and, running upon the

crus of the diaphragm, open into the thoracic duct close to its commencement. A similar set of lymphatics is found upon the left lobe of the liver; the vessels of which it is composed, after reaching the left lateral ligament, pierce the diaphragm, and, turning forwards, end in the glands in the anterior mediastinum. Finally, along the fore part of the liver, some vessels will be observed to turn downwards and join those placed upon its under surface.

The under surface of the liver is covered by an open network of lymphatic vessels. On the right lobe, they are directed over and under the gall-bladder to the transverse fissure, where some join the deep lymphatics; whilst others, after passing through some scattered lymphatic glands, are guided by the hepatic artery to the right side of the aorta, where they terminate in the thoracic duct. Branches also proceed to the concave border of the stomach, between the folds of the small omentum, to join with the coronary lymphatics of that organ.

[Fig. 272.



A front view of the femoral iliac and aortic lymphatic vessels and glands. 1. Saphena magna vein. 2. External iliac artery and vein. 3. Primitive iliac artery and vein. 4. The aorta. 5. Ascending vena cava. 6, 7. Lymphatics which are alongside of the saphena vein on the thigh. 8. Lower set of inguinal lymphatic glands which receive these vessels. 9. Superior set of inguinal lymphatic glands which receive these vessels. 10. The chain of lymphatics in front of the external iliac vessels. 11. Lymphatics which accompany the circumflex iliac vessels. 12. Lumbar and aortic lymphatics. 13. Afferent trunks of the lumbar glands, forming the origin of the thoracic duct. 14. Thoracic duct at its commencement.—S. & H.]

The *deep lymphatics* of the liver accompany the branches of the portal vein in the substance of the organ, and pass out of the gland by the transverse fissure. After communicating with the superficial lymphatics, and also with those of the stomach, they pass backwards, and, at the side of the cœliac artery, join with one of the *lacteal* trunks previously to its termination in the thoracic duct.

The absorbent vessels of the *intestines*, named the *lacteals*, have been already described (ante, page 44). So, too, have the mesenteric glands connected with those vessels (p. 45). It now remains to consider the other lymphatic glands situated in the pelvic and abdominal cavities.

The *lymphatic glands of the pelvis and abdomen* [fig. 272.]—The lymphatics of the lower half of the body may be followed, within the abdomen, to a continuous series of glands situated in front of the sacrum and vertebral

column. Though connected by absorbent vessels passing from one to the other, these glands are more numerous at particular points, and are accordingly arranged into several groups. In the pelvis, some of the glands are placed behind the rectum in the hollow of the sacrum, and are hence named *sacral lymphatic glands.* Others, again, surrounding the internal iliac artery are denominated the *internal iliac* glands. They receive the lymphatics corresponding to the branches of the internal iliac artery, and communicate upwards with the lumbar glands.

The *lumbar lymphatic glands* are very large and numerous; they are placed in front of the lumbar vertebræ, around the aorta and vena cava. To these may be traced the lymphatics of the lower limb, as well as those which accompany several of the branches of the abdominal aorta.

The efferent absorbent vessels which proceed from these glands progressively increase in size, while their number diminishes, and at length they unite into a few trunks, which, with those of the lacteals, form the origin of the thoracic duct.

THE LYMPHATICS OF THE THORAX.

The lymphatics of the thorax are divisible into two sets, viz., those derived from the walls, and those from the viscera of that cavity. The former are arranged in two distinct planes, one lying betwcen the skin of the muscles, the other being deeply seated. The superficial lymphatics at the front of the chest run upon the great pectoral muscle, and for the most part are directed towards the axilla, where they enter the lymphatic glands. Those upon the back lie on the trapezius and latissimus dorsi, and, inclining from various directions, also converge to the axilla, and end in the same series of glands as the lymphatics of the upper limb. The deep absorbents at the fore part of the chest correspond, in their general distribution, with the internal mammary artery: commencing in the muscles of the abdomen, they ascend between the fibres of the diaphragm at its attachment to the ensiform cartilage, and then continue behind the costal cartilages to the top of the thorax. In their course they receive branches from the anterior part of the intercostal spaces, and ultimately terminate on the left side in the thoracic duct, and on the opposite side in the right lymphatic duct.

The deep lymphatics at the sides and back part of the chest follow the distribution of the aortic intercostal arteries: they receive absorbent vessels which come forwards, through the intertransverse spaces, from the parts seated in the vertebral grooves, and other vessels from each side which run along the intercostal spaces. All these incline inwards to the spine, and terminate in the thoracic duct.

The *lymphatics of the lungs*, like those of other organs, form two sets, one being superficial, the other deep-seated. Those at the surface run beneath the pleura, where they form a network by their anastomoses. Their number is considerable, but they are sometimes difficult of demonstration. "I have been able,"* says Cruikshank, "at one time to show the whole external surface of the lungs covered

* Anatomy of the Absorbents, p. 194.

with absorbents I had injected ; at another time I have not been able to find one."

One of the easiest methods of finding them is to inflate the lungs of a still-born child from the trachea; the air passes from the cells into the absorbents, and enables us to see those on the surface : if a puncture be made into one of them with a lancet, the air will partially escape, and then the injecting pipe, containing a column of quicksilver, can be introduced.*

Most of these superficial lymphatics converge to the root of the lungs, and terminate in the bronchial glands.

The deep lymphatics of the lungs run with the blood-vessels along the bronchi: they communicate freely with those upon the surface, and at the root of the lungs open into the bronchial glands. From these, two or three trunks issue, which ascend along the trachea to the root of the neck, and terminate on the left side in the thoracic duct, and on the right in the lymphatic duct of that side.

The *lymphatics of the heart* follow the coronary vessels from the apex of the organ towards its base. Those of the right side meet near the origin of the aorta, so as to form a trunk of some size, which runs upwards over the aortic arch, and passes backwards between the innominate and left carotid arteries, to reach the trachea, along which it ascends to the root of the neck, to terminate in the right lymphatic duct. The left lymphatics of the heart ascend to the base of the organ ; where they communicate with the preceding set, and having united into a single vessel, proceed along the pulmonary artery, towards its bifurcation. At this point the vessel passes through some lymphatic glands behind the arch of the aorta, and ascends by the trachea to terminate in the thoracic duct.

The *lymphatics of the œsophagus* form along that tube a plexus of vessels, passing upwards upon it, and traversing the glands which lie in their course: after having communicated by anastomoses with the lymphatics of the lungs, at and near the roots of those organs, they terminate in the thoracic duct.

The lymphatics of the *thymus gland* and those of the *thyroid* body may be described with the absorbents of the thorax.

" On the spinal surface of the thymus gland," Sir Astley Cooper observes,† " numerous absorbent glands are found ; and if these be injected, many absorbents are discovered. But upon the posterior surface of the cornua and cervical portion, two large vessels proceed on each cornu, and the side of the trachea.—They pass nearly straight upon the spinal surface of the cornua, converging a little as they proceed towards the sternum, and terminate in the jugular veins by one or more orifices on each side."

The lymphatics of the thyroid gland.—From each lateral lobe of this organ some absorbing vessels arise, which converge and unite to form one short trunk, that opens at the right side into the right lymphatic duct, at the left into the thoracic duct. They may be demonstrated by inserting the injecting pipe into the substance of the gland, when the mercury, by its weight, will force its way into the lymphatics.

The lymphatic glands of the thorax.—In describing the vessels, mention has already been made of the glands through which they

* Loc. cit.

† Anatomy of the Thymus Gland, p. 14.

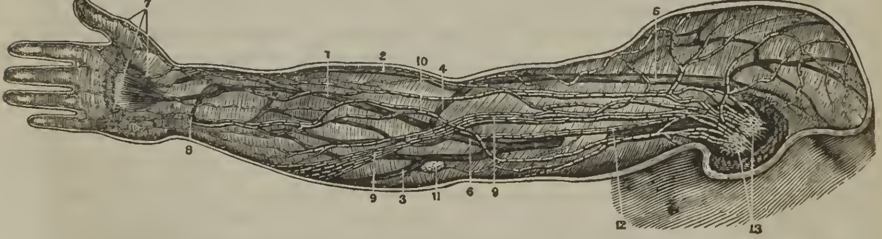
pass in various situations. Thus, along the course of the internal mammary blood-vessels there are placed six or seven small glands, through which the lymphatics behind the sternum pass; they may be named the *anterior mediastinal* glands. Three or four lymphatic glands (*cardiac*) lie behind the aortic arch, and one before it; and another cluster, varying from fifteen to twenty in number, are found along the œsophagus (*œsophageal glands*). At the root of the lungs there are ten or twelve glands of much larger size than those just mentioned. These are the *bronchial glands.* The largest of them occupy the interval between the right and left bronchi at their bifurcation, whilst others of smaller size rest upon these tubes for a short distance within the lungs. In early infancy their colour is pale red; towards puberty, we find them verging to gray, and studded with dark spots; at a more advanced age they are frequently very dark. In chronic diseases of the lungs they sometimes become enlarged and indurated, so as to press on the air-tubes, and cause much irritation. They are frequently the seat of tuberculous deposits.

LYMPHATICS OF THE UPPER LIMB.

In the upper limb, as in the lower, the lymphatics are arranged into a superficial and a deep set—the former accompanying the subcutaneous veins, the latter following the course of the deep blood-vessels.

The *superficial lymphatics* [fig. 273.] form two divisions, which correspond with the subcutaneous veins on the outer and inner borders of the forearm. One set accompanies the branches of the ulnar cutaneous vein from the inner border of the hand, along the front and inner side of the fore-arm as high as the bend of the elbow. In this course they receive numerous collateral branches, and join at the point just indicated with some of those from the outer side of the fore-arm. Continuing their course upwards along the arm, a few of them passing through a lymphatic gland situated in front of the inner condyle of the humerus, these absorbent vessels terminate either in glands placed along the brachial artery, or in those of the axilla, where they unite with the deep lymphatics. Those

[Fig. 273.



The superficial lymphatic vessels of the upper extremity.—1. The median vein. 2. Cephalic vein. 3. Posterior basilic vein. 4. Median cephalic. 5. Cephalic vein high up the arm. 6. Median basilic vein. 7. Superficial lymphatics of the hand. 8. Lymphatic trunks from the inside of the hand. 9, 9. Principal fasciculus of lymphatics from the front and back of the fore-arm. 10. A branch from the superficial to the deep lymphatics of the fore-arm. 11. An accidental lymphatic gland. 12. Superficial lymphatics which dip down with the basilic vein. 13. The lymphatic glands of the axilla, which receive the lymphatic vessels of the arm.—S. & H.]

which constitute the *second* set, placed along the outer border of the fore-arm, are less numerous than the preceding. They commence beneath the integuments on the outer and back part of the hand, and follow the course of the radial cutaneous veins to the bend of the elbow; here the greater number of them join the vessels last described, whilst a few ascend with the cephalic vein, on the outer side of the arm, and passing with that vessel between the deltoid and great pectoral muscles, end beneath the clavicle in one or more lymphatic glands, connected with those at the lower part of the neck.

The *deep* lymphatics of the upper limb correspond with the deep blood-vessels. In the fore-arm they consist, therefore, of three sets, associated with the radial, ulnar, and interosseous arteries and veins; in their progress upwards, they have frequent communications with the superficial lymphatics. Some of them enter the glands which lie near the brachial artery; and all terminate in the glands of the axilla.

The *axillary glands* are generally ten or twelve in number; in this respect, however, as well as in their size, they vary considerably in different individuals; they are placed along the axillary vessels, embedded in a quantity of loose cellular tissue, and a few are situated at some distance below the vessels, against the serratus magnus muscle. They receive all the lymphatics of the arm already described, as well as those proceeding from the integuments of the back, from the fore part of the thorax, and from the mammary gland. Hence they are liable to be influenced by diseases affecting any of those parts.

From the glands in the axilla, efferent lymphatic vessels, fewer in number, but larger in size than the afferent vessels, proceed along the course of the subclavian artery, in some parts twining round it. From the top of the thorax they ascend into the neck, close to the subclavian vein, and terminate, those of the left side in the thoracic duct, those of the right side in the right lymphatic duct. Sometimes they unite into a single trunk, which opens separately into the subclavian vein near its termination.

LYMPHATICS OF THE HEAD AND NECK.

The *lymphatics of the head* include those of the cranium and the face.

Commencing beneath the scalp, the lymphatics of the cranium join together so as to diminish in number whilst they increase in size, and are at length collected into an anterior and a posterior set, which follow respectively the course of the temporal and the occipital arteries. The *temporal* set descend in front of the ear, some of the vessels passing through one or two glands usually found near the zygoma, whilst others enter those situated on the parotid gland; all of them terminate in the lymphatic glands of the neck. The *occipital* set of the cranial lymphatics, accompanying the occipital artery, descends to the glands situated behind the ear (over the mastoid process of the temporal bone), and thence joins the superficial lymphatics of the neck.

Within the cranial cavity, lymphatic vessels have been demonstrated in the pia mater and in the arachnoid membrane. None have been injected in the dura mater, nor have they been shown in the sub-

stance of the brain. The trunks of those derived from the pia mater pass out of the skull with the veins.

The *superficial lymphatics of the face*, more numerous than those of the cranium, descend obliquely in the course of the facial vein, and join the glands placed beneath the base of the lower maxillary bone; a few of them in their descent pass through one or two glands situated over the buccinator muscle. The *deep* lymphatics of the *face* are derived from the cavities of the nose and mouth, and proceed in the course of the internal maxillary artery: having reached the angle of the jaw, they enter the glands situated in that place.

The *lymphatic glands* found on different parts of the *head* and *face* are few and very small: those of the *neck*, on the contrary, are comparatively large and very numerous.

The *cervical glands* are almost all placed on the sides of the neck, and are divisible into a superficial and a deep series. Of the former, some lie beneath the base of the inferior maxillary bone; the remainder, arranged along the course of the external jugular vein, occur in greatest number in the angular space behind the lower end of the sterno-mastoid muscle, where that vein enters the subclavian vein; at this point the cervical glands approach and are connected with the glands of the axilla. The *deep cervical* glands are placed along the carotid artery and internal jugular vein, extending downwards on the sheath of those vessels as far as the thorax.

The lymphatic vessels of the cranium and face (already described), together with those of the pharynx, larynx, and other parts of the neck, pass into the cervical glands. From these efferent vessels issue, which progressively diminish in number during their descent, and unite into a single trunk at the bottom of the neck. On the left side this single vessel usually enters the thoracic duct, close to its termination, and on the opposite side ends in the right lymphatic duct: sometimes, however, it terminates separately at the junction of the subclavian and internal jugular veins, or in one of those vessels, immediately before they unite.

EPIDERMIC, EPITHELIAL OR CUTICULAR TISSUE.

It is well known, that when the skin is blistered, a thin and nearly transparent membrane, named the cuticle or epidermis, is raised from its surface. In like manner, a transparent film may be raised from the lining membrane of the mouth, of the same nature as the epidermis, although it has in this situation received the name of "epithelium;" and under the latter appellation, a coating of the same kind exists on nearly all free surfaces of the body. It is true, that in many situations the epithelium cannot be actually raised from the subjacent surface as a coherent membrane, still its existence as a continuous coating can be demonstrated; and, although in different parts it presents other important differences, it has in all cases the same fundamental structure, and its several varieties are connected by certain common characters.

The existence of a cuticular covering in one form or other, has been demonstrated in the following situations: viz. 1. On the surface of the skin. 2. On mucous membranes; a class of membranes to be afterwards described, which line those internal cavities and passages of the body that open exteriorly, viz. the alimentary canal, the lachrymal, nasal, tympanic, respiratory, urinary and genital passages; as well as the various glandular recesses and ducts of glands, which open into these passages or upon the surface of the skin. 3. On the inner or free surface of serous membranes, which line the walls of closed cavities in the head, chest, abdomen, and other parts. 4. On the membranes termed synovial within the joints. 5. On the inner surface of the blood-vessels and lymphatics.

This tissue has neither vessels nor nerves, and it is wholly devoid of sensibility; it, nevertheless, possesses a decidedly organized structure. Wherever it may exist, it is formed essentially of nucleated cells united together by a more or less cohesive intercellular matter. The cells, in whatever way they may be produced, make their appearance first in the deepest part of the structure, in a soft blastema deposited by the blood-vessels of the subjacent tissue; then, usually undergoing considerable changes in size, figure, and consistency, they gradually rise to the surface, where, in most cases, and perhaps in all, they are thrown off and succeeded by others from beneath. In many situations the cells form several layers, in which they may be seen in different stages of their progress, from their first appearance to their final desquamation. The layer or layers thus formed, take the shape of surface to which

they are applied, following accurately all its eminences, depressions, or other inequalities.

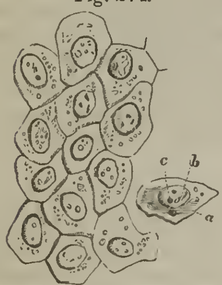
In accordance with the varied purposes which the epithelium is destined to fulfil, the cells of which it is composed come to differ in different situations, in their figure, their size, their position in respect of each other, their degree of mutual cohesion, and in the nature of the matter they contain, as well as the vital endowments which they manifest; and, founded on these modifications of its constituent cells, four principal varieties of epithelium have been recognised, namely, the *scaly*, the *columnar*, the *spheroidal*, and the *ciliated*, each of which will now be described in particular.

It may first be remarked, however, that amidst these changes the nucleus of the cell undergoes little alteration, and its characters are accordingly remarkably uniform throughout. It is round or oval, and more or less flattened; its diameter measures from $\frac{1}{6000}$ to $\frac{1}{4000}$ of an inch, or more. Its substance is insoluble in acetic acid, and colourless, or has a pale reddish tint. It usually contains one or two nucleoli, distinguished by their strong, dark outline; and a variable number of more faintly-marked granules irregularly scattered. For the most part, the nucleus is persistent, but in some cases it disappears from the cell.

The *scaly*, *lamellar*, *tabular*, or *flattened* epithelium (pavement, or tessellated epithelium of the German anatomists). In this variety the epithelium particles have the form of small angular tables, or thin scales; in some situations, forming a single thin layer, in others accumulating in many superimposed strata, so as to afford to the parts they cover a defensive coating of considerable strength and thickness.

As a *simple layer*, it is found on the serous membranes, the inner surface of the heart, the blood-vessels, and absorbents.

Fig. 274.



Fragment of epithelium from a serous membrane (peritoneum,) magnified 410 diameters. *a*, cell; *b*, nucleus; *c*, nucleoli.—(Henlé.)

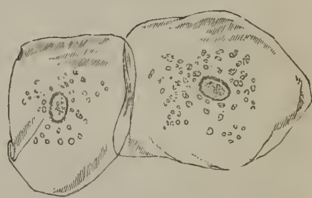
If the surface of the peritoneum, pleura, pericardium or other serous membrane be gently scraped with the edge of a knife, a small quantity of soft matter will be brought away, which, when examined with the microscope, will be found to contain little shred-like fragments of epithelium, in which a greater or less number of its constituent particles still hold together, like the pieces composing a mosaic work (fig. 274.) These particles, which are flattened cells, have, for the most part, a polygonal figure, and are united to each other by their edges. Each has a nucleus in or near the centre. The addition of weak acetic acid renders the angular outline of the cells as well as the nucleus more distinct. The cells differ somewhat in size on different parts of the serous membrane.

The epithelium of the vascular system resembles in many parts that of the serous membranes; but in some situations the flattened cells, together with their nuclei, assume an oblong figure, and sometimes their outline becomes indistinct from blending of neighbouring cells.

A scaly epithelium in which the cells form several layers, (thence named "stratified," by Henlé,) covers the skin, where it constitutes the scarf-skin, or epidermis, which, together with the hairs and nails, will be afterwards more fully described. In this form it exists, also, on the conjunctival covering of the eyeball; on the membrane of the nose for a short distance inwardly; on the tongue and the inside of the mouth, throat, and gullet; on the vulva and vagina, extending some way into the cervix of the uterus; also (in both sexes) on a very small extent of the membrane of the urethra, adjoining the external orifice. It is found, also, on the synovial membranes which line the joints. Its principal use, no doubt, is to afford a protective covering to these surfaces, which are almost all more or less exposed to friction.

The cells in this sort of epithelium become converted into broad thin scales, which are loosened and cast off at the free surface. Such scales, both single and connected in little patches, may be at all times seen with the microscope, in mucus scraped from the inside of the mouth, as shown in fig. 275; but to trace the progressive change of the cells, they must be successively examined at different depths from the surface, and the epithelium must also be viewed in profile, or in a perpendicular section, as exhibited in figure 276. In this manner, at the deep or attached surface, small cells may be seen in the midst of a soft granular, or clear substance (blastema). These appear to be recently formed, for their cell membrane closely invests the nucleus; nay, it is alleged by good observers, that mere nuclei are also present, which subsequently acquire an envelope. A little higher up in the mass the cells are enlarged; they have a globular figure, and are filled with soft matter; they next become flattened, but still retain their round or oval outline; then the continued flattening causes their opposite sides to meet and cohere, except where separated by the nucleus, and they are at length converted into thin scales, which form the uppermost layers. While they are undergoing this change of figure, their substance becomes more firm and solid, and their chemical nature is more or less altered; for the cell-membrane of the softer and more deep-seated cells may be dissolved by acetic acid, which is not the case with those nearer the surface. The nucleus at first enlarges, as well as the cell, but in a much less degree; and it soon becomes stationary in its growth, having usually acquired an oval figure, and an eccentric position. The scales near the surface overlap a little at their edges, and their figure is very various; somewhat deeper it is mostly polygonal, and more uniform. Besides the nuclei, they often exhibit small scattered granules, like dots, and, according to Henlé, are sometimes marked over with fine parallel lines.

Fig. 275.

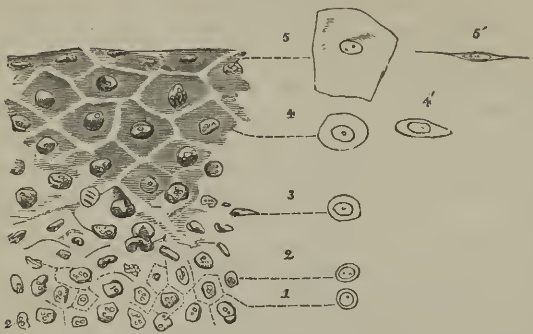


Epithelium scales from the inside of the mouth, magnified 260 diameters. (Henlé.)

In various parts, the more superficial and denser layers of the scaly

epithelium can be readily separated from the deeper, more recently formed, and softer part which lies underneath; and this has led to the

Fig. 276.

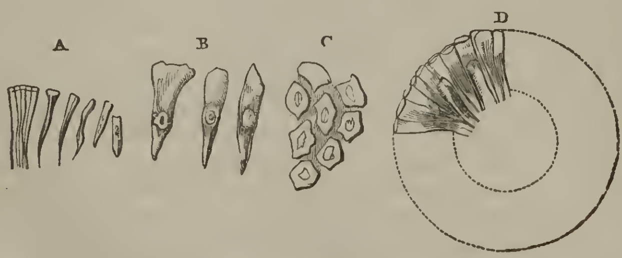


Epithelium from the conjunctiva of the calf, folded so that the free surface forms the upper border of the figure, and rendered transparent by acetic acid. 1, 2, 3, 4, 5, progressive flattening of the cells as they rise to the surface. The outline figures represent single cells from different depths, viewed on their surface; and at 4′ and 5′, edgeways. Magnified 410 diameters. (Chiefly after Henlé.)

error of describing the latter as a distinct membrane, under the name of *rete mucosum;* this point will be again noticed in treating of the skin.

Columnar Epithelium.—In this variety, (figs. 277 and 278,) the constituent cells are elongated in a direction perpendicular to the surface of the membrane, so as to form short upright columns, smaller or even pointed at their lower or attached extremity, and broader at the upper. They are mostly flattened on their sides, by which they are in mutual apposition, at least in their upper and broader part, and have, therefore, so far a prismatic figure, their broad flat ends appearing at the surface of the epithelium, in form of little polygonal areas (fig. 277 C.) The nucleus, usually oval, is placed near the middle of the column, and is often so large, in proportion to the cell, as to cause a bulging at that part; in which case, Mr. Bowman* observes, the height of the nucleus differs in contiguous columns, the better to allow

Fig. 277.



A, B, columns of epithelium from the intestine, magnified. C. Viewed by their broad free extremity. D. Seen in a transverse section of an intestinal villus. (From Henlé.)

of mutual adaptation. The particles from the epithelium of the gall-bladder, are mostly without nuclei (Henlé). Besides the nucleus, the columnar cell usually contains a certain amount of an obscurely granular matter; this may be distributed throughout the whole of the particle, or confined to its middle and lower end, the upper part of the column remaining transparent; or lastly, the granular matter may be surrounded on all sides by a transparent border, which some have supposed to be the wall of the cell.

The little columns are held together, though sometimes very feebly, by intercellular substance, which fills up the wider space between their narrow ends, and even extends beyond their large extremities, and forms a continuous layer over them on the free surface of the epithelium.

Fig. 278.

Columns of epithelium from the rabbit's intestine. 1. Free surface. 2. Broad outer end. 3. Nucleus. 4. Small inner extremity turned towards the mucous membrane. 308 diameters. —(Henlé.)

The columnar epithelium is unquestionably subject to shedding and renovation, but the precise mode in which this takes place has not been ascertained.

Valentin infers, from his observations, that in most parts there are young cells in successive stages of advancement, lying underneath the columnar particles, and preparing to take their place, as occurs in the cuticle and other corresponding forms of the scaly epithelium. But in some situations, the little columns appear to rest immediately on the subjacent membrane, without any appearance of an intervening layer. Perhaps the epithelial coating may not undergo a slow and continual shedding and renewal, but may from time to time be cast off entirely and at once;† in which case, the subjacent surface may remain denuded for a short time, until its covering is restored, or a new epithelium may be formed preparatory to the shedding of the old, and ready to succeed it. Some have supposed,‡ that a temporary denudation takes place in certain situations and circumstances; it has been stated, for instance, that the epithelium is thrown off from the inner surface of the intestines, during digestion, in order to enable the subjacent membrane to exercise the special function, and that, when this is accomplished, the epithelial covering is speedily reproduced. Others§ consider the separation of the epithelium in these cases as accidental.

The columnar variety of epithelium is confined to mucous membranes. It is found in the stomach; on the mucous membrane of the intestines in its whole extent; in the whole length of the urethra, except a small part at the orifice. It extends along the ducts of the greater number of glands, whether large or small, which open on the mucous membrane, but not through their entire length; for, at their extremities, these ducts have an epithelium of a different character. The inner membrane of the gall-bladder is covered with columnar epithelium.

Spheroidal epithelium.—In this variety, the cells for the most part retain their primitive roundness, or, being flattened where they touch,

* Cyclopedia of Anatomy, art. Mucous Membrane.

† [This I have observed to be undoubtedly the case in insects and crustacea.—J. L.]

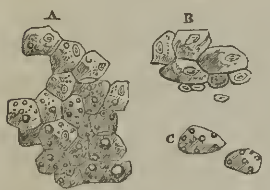
‡ Goodsir, Edin. New Phil. Journal, vol. xxxiii. Mr. G. thinks, that the primary or basement membrane which lies immediately underneath the epithelium, contains persistent and proligerous nuclei, which serve as reproductive centres for new epithelium cells.

§ Reichert and Bidder. Müller's Archiv. 1843; Jahresbericht, p. 231. Bidder found, that when proper care was taken, the gastric, as well as intestinal epithelium, was always entire.

acquire a polyhedral figure, in which no one dimension remarkably predominates. Hence, the above term was applied to this form of epithelium by Mr. Bowman.* But in some places the cells show a tendency to lengthen into columns, and in others to flatten into tables, especially when this epithelium approaches the confines of one or other of the preceding varieties; in such cases Henlé names it *transitional;* moreover, when the scaly and columnar varieties border with one another, the figure of their particles is gradually changed, presenting various intermediate forms; in other words, the epithelium there puts on the transitional character, though it may be only for a very small space.

The greatest stretch of spheroidal epithelium is found in the urinary passages, where it succeeds the columnar epithelium of the urethra at the internal orifice of that canal, and lines the whole of the bladder, ureters, and pelves of the kidneys. It is found also in the excretory ducts of the mammary, perspiratory, and of many mucous glands, and a modification of the spheroidal epithelium lines the inmost secreting cavities, or commencing ducts of glands generally (fig. 279). In this last-mentioned situation, the nucleated cells contain a large proportion of fine granular matter; in some cases even, the peculiar ingredients of the secretion may be recognised in them; and it is conceived, that they have a considerable share in preparing or separating these matters from the blood.

Fig. 279.



Cells from the liver, magnified. —(Dr. Baly.)

Ciliated Epithelium.—In this form of epithelium, the particles, which are generally columnar, bear at their free extremities little hair-like processes, which are agitated incessantly during life, and for some time after death, with a lashing or vibrating motion. These minute and delicate-moving organs are named *cilia.* They have now been discovered to exist very extensively throughout the animal kingdom; and the movements they produce are subservient to very varied purposes in the animal economy.

In the human body the ciliated epithelium occurs in the following parts,† viz.:—1. On the mucous membrane of the air passages and its prolongations. It commences at a little distance within the nostrils, covers the membrane of the nose and of the adjoining bony sinuses, extends up into the nasal duct and lachrymal sac, is interrupted then by scaly epithelium which lines the lachrymal canals, but reappears on the conjunctiva of the eyelids. From the nose it spreads backwards a certain way on the upper surface of the soft palate, and into the upper or nasal region of the pharynx; also into the eustachian tube, and tympanum. The remainder of the pharynx is covered by scaly epithelium as already mentioned; but the ciliated epithelium begins again in the larynx a little above the glottis, and continues throughout the trachea and the bronchial tubes in the lungs to their smallest rami-

* Cyclop. of Anat., art. Mucous Membrane.
† Henlé, Allgemeine Anatomie, p. 246.

fications. 2. On the mucous lining of the uterus and fallopian tubes, and even on the peritoneal surface of the latter at their fimbriated extremities. 3. On the parietes of the ventricles of the brain.

In other mammiferous animals as far as examined, cilia have been found in nearly the same parts. To see them in motion, therefore, a portion of ciliated mucous membrane may be taken from the body of a recently killed quadruped. The piece of membrane is to be folded with its free or ciliated surface outwards, placed on a slip of glass, with a little water or serum of blood, and covered with a bit of thin glass or mica. When it is now viewed with a magnifying power of 200 diameters, or upwards, a very obvious agitation will be perceived on the edge of the fold, and this appearance is caused by the moving cilia with which the surface of the membrane is covered. Being set close together, and moving simultaneously or in quick succession, the cilia, when in brisk action, give rise to the appearance of a bright transparent fringe along the fold of the membrane, agitated by such a rapid and incessant motion, that the single threads which compose it cannot be perceived. The motion here meant, is that of the cilia themselves; but they also set in motion the adjoining fluid, driving it along the ciliated surface, as is indicated by the agitation of any little particles that may accidentally float in it. The fact of the conveyance of fluids and other matters along the ciliated surface, as well as the direction in which they are impelled, may also be made manifest by immersing the membrane in fluid, and dropping on it some finely pulverized substance, (such as charcoal in fine powder,) which will be slowly but steadily carried along in a constant and determinate direction; and this may be seen with the naked eye, or with the aid of a lens of low power.

The ciliary motion of the human mucous membrane is beautifully seen on the surface of recently extracted nasal polypi; and single ciliated particles, with their cilia still in motion, are sometimes separated accidentally from mucous surfaces in the living body, and may be discovered in the discharged mucus; or they may even be purposely detached by gentle abrasion. But the extent and limits of the ciliated epithelium of the human body have been determined chiefly from its anatomical characters.

Cilia have now been shown to exist in almost every class of animals, from the highest to the lowest. The immediate purpose which they serve is, to impel matters, generally more or less fluid, along the surfaces on which they are attached; or, to propel through a liquid medium the ciliated bodies of minute animals, or other small objects on the surface of which cilia are present; as is the case with many infusorial animalcules, in which the cilia serve as organs of locomotion, like the fins of larger aquatic animals, and as happens, too, in the ova of many vertebrated as well as invertebrate animals, where the yolk revolves in its surrounding fluid by the aid of cilia on its surface. In many of the lower tribes of aquatic animals, the cilia acquire a high degree of importance; producing the flow of water over the surface of their organs of respiration, indispensable to the exercise of that function; enabling the animals to seize their prey, or to swallow

their food, and performing various other offices of greater or less importance in their economy. In man, and the warm-blooded animals, their use is apparently to impel secreted fluids, or other matters, along the ciliated surfaces, as, for example, the mucus of the wind-pipe and nasal sinuses, which they carry towards the outlet of these cavities.

The cells of the ciliated epithelium (figs. 280 and 281), contain nuclei, as usual; they have most generally an elongated or prismatic form, like the particles of the columnar epithelium, which they resemble, too, in arrangement. The cilia are attached to their broad or

Fig. 280.

Columnar ciliated epithelium cells from the human nasal membrane. Magnified 300 diameters.

Fig. 281.

Spheroidal ciliated cells from the mouth of the frog. Magnified 300 diameters.

superficial extremities, each columnar particle bearing a tuft of these minute hair-like processes. In some cases, the cells are spheroidal in figure, the cilia being still, of course, confined to that portion of the cell which forms part of the general surface of the epithelial layer (fig. 281). Instances of the latter form occur in the epithelium of the frog's mouth, on the surface of the ovum, and, according to Valentin,* on the choroid plexuses of fœtal quadrupeds.

The cilia themselves differ widely in size in different animals, and they are not equal in all parts of the same animal. In the human windpipe they are, according to Valentin's measurement, $\frac{1}{4000}$ to $\frac{1}{2500}$ of an inch long; but in many invertebrate animals, especially such as live in salt water, they are a great deal larger. In figure they have the aspect of slender, conical, or slightly flattened filaments; broader at the base and usually pointed at their free extremity. Their substance is transparent, soft, and flexible. It is to all appearance homogeneous, and no fibres, granules, or other indications of definite internal structure, have been satisfactorily discovered in it.

There is reason to believe, that the ciliated epithelium of the uterus is from time to time shed and renewed; and, probably, the same change may take place, though more gradually and less perceptibly, on other ciliated surfaces. But nothing is known of the process by which this is effected.

The manner in which the cilia move, is best seen when they are not acting very briskly. Most generally they seem to execute a sort of fanning or lashing movement; and when a number of them perform this motion in regular succession, as is generally the case, they give rise to the appearance of a series of waves travelling along the range of cilia, like the waves caused by the wind in a field of wheat. When they are in very rapid action, the undulation is less obvious, and, as

* Wagner's Handwörterbuch der Physiologie, art. Flimmerbewegung.

Henlé remarks, their motion then conveys the idea of swiftly-running water. The undulating movement may be beautifully seen on the gills of a mussel, and on the arms of many polypes. The undulations, with some exceptions, seem always to travel in the same direction on the same parts. The impulsion, also which the cilia communicate to the fluids or other matters in contact with them, maintains a constant direction, unless in certain of the infusoria, and in these the motion has even been supposed to be voluntary. Thus, in the windpipe of mammalia, the mucus is conveyed upwards towards the larynx, and if a portion of the membrane be detached, matters will still be conveyed along the surface of the separated fragment in the same direction relatively to that surface, as before its separation.

The persistence of the ciliary motion for some time after death, and the regularity with which it goes on in parts separated from the rest of the body, sufficiently prove that, with the possible exceptions alluded to, it is not under the influence of the will of the animal nor dependent for its production on the nervous centres, and it does not appear to be influenced in any way by stimulation or sudden destruction of these centres. The time which it continues after death or separation differs in different kinds of animals, and is also materially influenced by temperature and by the nature of the fluid in contact with the surface. In warm-blooded animals the period varies from two or three hours to two days, or even more; being longer in summer than in the cold of winter. In frogs the motion may continue four or five days after destruction of the brain; and it has been seen in the gullet of the tortoise fifteen days after decapitation, continuing seven days after the muscles had ceased to be irritable.

With the view of throwing further light on the nature of this remarkable kind of motion, experiments have been made to ascertain the effect produced on it by different external agents; but it would seem that, with the exception perhaps of moderate heat and cold, these agents affect the action of the cilia only in so far as they act destructively on their tissue.

The effect of change of temperature is different in warm and cool-blooded animals. In the former the motion is stopped by a cold of 43° F., whereas in the frog and river-mussel, it goes on unimpaired at 32° F. A moderately elevated temperature, say 100° F., does not affect the motion in cold-blooded animals, but, of course, a heat considerably higher than this, and such as to alter the tissue, would put an end to it in all cases. Electric shocks, unless they cause abrasion of the ciliated surface, (which is sometimes the case,) produce no visible effect; and the same is true of galvanic currents. Fresh water, I find, arrests the motion in marine mollusca and in other salt-water animals in which I have tried its effect, but it evidently acts by destroying both the form and substance of the cilia, which in these cases are adapted to a different medium. Most of the common acid, alkaline, and saline solutions, when concentrated, arrest the action of the cilia instantaneously in all animals; but dilution delays this effect, and when carried farther, prevents it altogether; and hence it is, probably, due to a chemical alteration of the tissue. Narcotic substances, such as hydrocanic acid, salts of morphia and strychnia, opium and belladonna, are said by Purkinje and Valentin to have no effect, though the first-named agent has certainly appeared to me to arrest the motion in the river-mussel. Bile stops the action of the cilia, while blood prolongs it in vertebrated animals; but the blood or serum of the vertebrata has quite an opposite effect on the cilia of invertebrate animals, arresting their motion almost instantaneously.

It must be confessed that the nature and source of the power by which the cilia act, are as yet unknown; but whatever doubt may hang over this question, it is plain that each ciliated cell is individually endowed with the faculty of producing motion, and that it possesses in itself whatever organic apparatus and whatever physical or vital property may be necessary for that end; for single epithelium cells are seen to exhibit the phenomenon long after they have been completely insulated.

Without professing to offer a satisfactory solution of a question beset with so much difficulty, it seems, nevertheless, not unreasonable to consider the ciliary motion as being probably a manifestation of that property on which the more conspicuous motions of animals are known to depend, namely, vital contractility; and this view has at least the advantage of referring the phenomenon to the operation of a vital property, already recognised as a source of moving power in the animal body.

It is true that nothing resembling a muscular apparatus, in the ordinary sense of the term, has been discovered to be connected with the cilia, nor is it necessary to suppose the existence of any such; for it must be remembered that vital contractility is not limited to a tissue strictly defined in its appreciable structure. The anatomical characters of voluntary muscle differ widely from those of most involuntary contractile textures, although the movements must in both cases be referred to the same principle. The heart of the embryo beats while yet but a mass of cells, united, to all appearance, by amorphous matter, in which no fibres are seen; yet no one would doubt that its motions depend then on the same property as at a later period, when its structure is fully developed.

In its persistence after systemic death, and in parts separated from the rest of the body, the ciliary motion agrees with the motion of certain muscular structures, as the heart for example; and the agreement extends even to the regular or rhythmic character of the motion in these circumstances. It is true, the one endures much longer than the other; but the difference appears to be one only of degree, for differences of the same kind are known to prevail among muscles themselves. No one, for instance, doubts that the auricle of the heart is muscular, because it beats longer after death than the ventricle; nor, because a frog's heart continues to act a much longer time than a quadruped's, is it inferred that its motion depends on a power of a different nature. And the view here taken of the nature of the ciliary motion derives strength from the consideration that the phenomenon lasts longest in cold-blooded animals, in which vital contractility also is of longest endurance. It must be allowed, unless we distrust the observations of very competent inquirers, that narcotic substances do not in general affect the cilia, while they are generally admitted to alter or extinguish muscular action. At the same time there remains some ambiguity on this head; my own observations do not agree in all points with those referred to, and Ehrenberg states that strychnia produces the same effect on the cilia of infusoria as on muscular organs. Something, moreover, may depend on the facility or difficulty with which the tissues permit the narcotic fluid to penetrate, which circumstance must needs affect the rapidity and extent of its operation. In the effect of opium on the heart there is a great difference, according as the narcotic is applied to its outer or its inner surface; and to this must be added that the effect of narcotics has not been carefully tried on all contractile tissues. Again, we see differences in the mode in which the cilia themselves are affected by the same agent: thus fresh water instantly arrests their motion in certain cases, while it has no such effect in others.

The discovery lately announced,* that vibrating cilia exist on the ova of certain cryptogamic vegetables, may perhaps be deemed a strong argument on the opposite side; but it is by no means proved that the sensible motions of plants, (such, at least, as are not purely physical,) and those of animals, do not depend on one common vital property.

* Unger. Die Pflanze im Momente der Theirwerdung. Wien, 1843. This naturalist has discovered that the movements of the sporidia of the Vaucheria Clavata are produced by vibratile cilia. The observation has since been confirmed by Siebold.

PIGMENT.

The cells of the cuticle, and of other textures which more or less resemble it in structure, sometimes contain a black or brown matter, which gives a dark colour to the parts over which these cells are spread. A well-marked example of such pigment-cells in the human body is afforded by the black coating which lines the choroid membrane of the eye and covers the posterior surface of the iris. They are found in the epidermis of the negro and other dark races of mankind, and are probably present in the more dusky parts of the cuticle of the European. They have been found also on certain parts of the investing membrane (pia mater) of the spinal cord, and in the membranous labyrinth of the ear.

The pigment cells of the choroid membrane (fig. 282) are for the most part polyhedral in figure, most generally six-sided, and connected together like the pieces of a mosaic pavement; others are spheroidal, and most of those on the back of the iris are of this shape. The cells contain the pigment, strictly so called, which consists of minute black or brown granules or molecules of a round or oblong shape, measuring not more than from $\frac{1}{17000}$ to $\frac{1}{24000}$ of an inch in their greatest dimension. These molecules are densely packed together in some cells; in others they are more scattered, and then it may be seen that there is a certain amount of colourless matter included along with them. When they escape from the ruptured cells, they exhibit very strikingly the molecular movement. It is worthy of remark, that when viewed singly with a very high magnifying power they look transparent and almost colourless, and it is only when they are heaped together that their blackness distinctly appears. The cells have a colourless nucleus, which is very generally hidden from view by the black particles. It contains a central nucleolus.

[Fig. 282.

Cells from pigmentum nigrum; *a.* pigmentary granules concealing the nucleus; *b*, the nucleus distinct Magnified 410 diameters.—C.]

Examined chemically, the black matter is found to be insoluble in cold and hot water, alcohol, ether, fixed and volatile oils, acetic and diluted mineral acids. Its colour is discharged by chlorine. The pigment of the bullock's eye, when purified by boiling in alcohol and ether, was found by Scherer to consist of 58·672 carbon, 5·962 hydrogen, 13·768 nitrogen, and 21·598 oxygen; its proportion of carbon is thus very large. Preceding chemists had obtained from its ashes oxide of iron, chloride of sodium, lime, and phosphate of lime.

The dark colour of the negro is known to have its seat in the cuticle, and chiefly in the deeper and softer part [fig. 283, *a*,] named the rete mucosum. According to Henlé, it is caused by the presence of pigment cells, resembling those of the choroid in almost every respect save their size, which is somewhat less. These are intermixed with colourless cells, and on the proportion of the two the depth of colour of different parts depends. According to the same authority, the darker parts of the European skin owe their colour to pigment cells like those of the negro, only still smaller in size, less defined in their outline, and less numerous. Krause affirms that the dark colour of the cuticle both of the negro and white races depends chiefly on the presence of cells which have dark brown nuclei, the substance of the cell being also tinged, but less deeply than the nucleus, and the colour being diffused through the mass and not caused by molecules. He admits that a few true pigment cells exist in the negro's skin. But whatever be the structure of the colouring particles, it cannot be doubted that in the skin the matter is the same in its essential nature as in the choroid. In albino individuals, both of the negro and European races, in whom the black matter of the choroid is wanting, the cuticle and the hair are colourless also.

[Fig. 283.

Vertical section of the cuticle, from the scrotum of a negro. *a*. Deep cells, loaded with pigment. *b*. Cells at a higher level, paler and more flattened. *c*. Cells at the surface, scaly and colourless as in the white races. Magnified 300 diameters.—Todd and Bowman.]

In some situations the pigment cells become irregular and jagged at their edges, or even branch out into long irregular processes. Such ramified cells are very common in many animals, as those from the skin of the frog represented in vol. i. fig. 16. In the human body pigment cells of this description are found in the dark cellular membrane between the sclerotic and choroid coats of the eye, and on the pia mater covering the upper part of the spinal cord. The condition of the pigment in the hairs will be afterwards described.

From the observations of Valentin on the choroid membrane of the embryo bird, it appears that the pigment cells are formed round previously existing nuclei, and that they are at first colourless, but that black molecules subsequently appear in them, first immediately round the nucleus, and afterwards throughout the rest of the cell.

When the cuticle of the negro is removed by means of a blister, it is renewed again of its original dark hue; but if the skin be destroyed to any considerable depth, as by a severe burn, the resulting scar remains long white, though it at length acquires a dark colour.

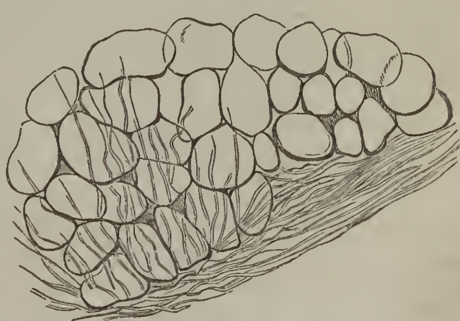
In the eye the black matter seems obviously intended to absorb redundant light, and accordingly its absence in albinos is attended with a difficulty of bearing a light of considerable brightness. Its uses in other situations are not so apparent. The pigment of the cuticle, it has been supposed, may screen the subjacent cutis from the pungency of the sun's rays. In many animals the pigment is not only employed to variegate the surface of the body, but attaches itself to deep-seated parts. Thus, in the frog the branches and twigs of the blood-vessels are speckled over with it, and in many fish it imparts a black colour to the peritoneum and other internal membranes.

ADIPOSE TISSUE.

The human body in the healthy state contains a considerable amount of fatty matter of different kinds. Fat, as already mentioned, is found in the blood and chyle, and in the lymph, but much more sparingly. It exists, too, in several of the secretions, in some constituting the chief ingredient; and in one or other of its modifications it enters into the composition of certain solid textures. But by far the greater part of the fat of the body is inclosed in small cells or vesicles, which, together with their contained matter, constitute the adipose tissue.

This tissue is not confined to any one region or organ, but exists very generally throughout the body, accompanying the still more widely-distributed cellular or areolar tissue in most though not in all parts in which the latter is found. Still, its distribution is not uniform, and there are certain situations in which it is collected more abundantly. It forms a considerable layer underneath the skin, and, together with the subcutaneous cellular tissue in which it is lodged, constitutes in this situation what has been called the *panniculus adiposus.* It is collected in large quantity round certain internal parts, especially the kidneys. It is seen filling up the furrows on the surface of the heart, and imbedding the vessels of that organ underneath its serous covering; and in various other situations it is deposited beneath the serous membranes, or is collected between their folds as in the mesentery and omentum, at first generally gathering along the course of the blood-vessels, and at length accumulating very copiously. Collections of fat are also common round the joints, lying on the outer surface of the synovial membrane, and filling up inequalities; in many cases, like the fat in the omentum, lodged in folds of the membrane which project into the articular cavity. Lastly, the fat exists in large quantity within the bones, where it forms the marrow. There are some parts in which fat is never found in the healthy condition of the body. Thus it does not exist in the subcutaneous cellular tissue of the eyelids, penis, or scrotum, nor in the lungs, nor within the cavity of the cranium.

Fig. 284.



A small cluster of fat-cells magnified 150 diameters.

When subjected to the microscope, the adipose tissue (fig. 284) is seen to consist of minute vesicles, filled with an oily matter, and for the most part lodged in the meshes of the areolar tissue. The

vesicles are most commonly collected into little lobular clusters, and these again into the little lumps of fat which we see with the naked eye, and which in some parts are aggregated into round or irregular masses of considerable magnitude. Sometimes the vesicles, though grouped together, have less of a clustered arrangement, as when they collect alongside of the minute blood-vessels of thin membranous structures.

The vesicles or fat-cells are round or oval, unless where packed closely together, in which case they acquire an angular figure, and bear a striking resemblance to the cells of vegetable tissues. The greater number of them are from $\frac{1}{300}$ to $\frac{1}{600}$ of an inch in diameter, but may exceed or fall short of this measurement. Each one consists of a very delicate envelope, enclosing the oily matter. The envelope is generally quite transparent, and appears to be homogeneous in structure, though in some cases its aspect is very faintly granular. Schwann discovered a nucleus in the fat-cells of the embryo; the nucleus contains one or two nucleoli, and is attached to the inside of the cell-wall or imbedded in its substance; it is rarely found in cells of later periods.

The oily matter contained in the cells is liquid, but in fat taken from the human body after death many of the cells present a stellated crystalline spot in their interior, as if a partial solidification had taken place; this may be due to separation and deposit of margarine, the solid constituent of human fat. The chemical nature of fat has been already explained (vol. i. p. 47).

[Fig. 285.

Blood-vessels of Fat:—1. Minute flattened fat-lobule, in which the vessels only are represented. 3. The terminal artery. 4. The primitive vein. 5. The fat vesicles of one border of the lobule, separately represented. Magnified 100 diameters.—2. *Plan* of the arrangement of the capillaries on the exterior of the vesicles: more highly magnified.—Todd and Bowman.]

The fat being thus contained in closed cells, it will be readily understood why, though liquid or nearly so in the living body, it does not shift its place in obedience to pressure or gravitation, as happens with

the water of dropsy and other fluids effused into the interstices of the cellular tissue; such fluids, being unconfined, of course readily pass from one place to another through the open areolæ.

The cellular tissue connects and surrounds the larger lumps of fat, but forms no special envelope to the smaller clusters; and although fine fasciculi and filaments of that tissue pass irregularly over and through the clusters, yet it is probable that the vesicles are held together in these groups mainly by the fine network of capillary vessels distributed to them. In the marrow the cellular tissue is very scanty; indeed the fat-cells in some parts of the bones are said to be altogether unaccompanied by cellular filaments.

The adipose tissue is copiously supplied with blood-vessels [fig. 286.] The larger branches of these pass into the fat lumps, where they then run between the lobules and subdivide, till at length a little artery and vein are sent to each small lobule, dividing into a network of capillary vessels, which not only surrounds the cluster externally, but passes through between the vesicles in all directions, supporting and connecting them. The lymphatics of the fat, if it really possesses any, are unknown. Nor have nerves been seen to terminate in it, though nerves destined for other textures may pass through it. Accordingly it has been observed that, unless when such traversing nervous twigs happen to be encountered, a puncturing instrument may be carried through the adipose tissue without occasioning pain.

As to the uses of the fatty tissue, it may be observed, in the first place, that it serves the merely mechanical purpose of a light, soft, and elastic packing material to fill vacuities in the body. Being thus deposited between and around different organs, it affords them support, facilitates motion, and protects them from the injurious effects of pressure. In this way, too, it gives to the exterior of the body its smooth rounded contour. Further, being a bad conductor of heat, the subcutaneous fat must so far serve as a means of retaining the warmth of the body, especially in warm-blooded creatures exposed to great external cold, as the whale and other cetaceous animals, in which it forms a very thick stratum, and must prove a much more effectual protection than a covering of fur in a watery element.

But the most important use of the fat consists in its subserviency to the process of nutrition. Composed chiefly of carbon and hydrogen, it is absorbed into the blood and consumed in respiration, combining with oxygen to form carbonic acid and water, and thus contributing with other hydrocarbonous matters to maintain the heat of the body; and it is supposed that when the digestive process introduces into the system more carbon and hydrogen than is required for immediate consumption, the excess of these elements is stored up in the form of fat, to become available for use when the expenditure exceeds the immediate supply. According to this view, active muscular exercise, which increases the respiration, tends to prevent the accumulation of fat by increasing the consumption of the hydrocarbonous matter introduced into the body. Again, when the direct supply of calorific matter for respiration is diminished or cut off by withholding food, or by interruption of the digestive process, nature has recourse to that which has been reserved in the form of fat; and in the wasting of the body caused by starvation, the fat is the part first consumed.

The use of the fat in nutrition is well illustrated by what occurs in the hedgehog and some other hybernating animals. In these the function of alimentation is suspended during their winter sleep, and though their respiration is reduced to the lowest amount compatible with life, and their temperature falls, there is yet a considerable amount of hydrocarbonous material provided in the shape of fat before their hybernation commences, to be slowly consumed during that period,

or perhaps to afford an immediate supply on their respiration becoming again active in spring.

It has been estimated that the mean quantity of fat in the human subject is about one-twentieth of the weight of the body, but from what has been said, it is plain that the amount must be subject to great fluctuation. The proportion is usually greatest about the middle period of life, and greatly diminishes in old age. High feeding, repose of mind and body, and much sleep, favour the production of fat. To these causes must be added individual and perhaps hereditary predisposition. There is a greater tendency to fatness in females than males, also, it is said, in eunuchs. The effect of castration in promoting the fattening of domestic animals is well known.

In infancy and childhood the fat is confined chiefly to the subcutaneous tissue. In after life it is more equally distributed through the body, and in proportionately greater quantity about the viscera. In Hottentot females, fat accumulates over the gluteal muscles, forming a considerable prominence, and in a less degree over the deltoid; a tendency to local accumulation of the subcutaneous fat is known to exist also in particular races of quadrupeds.

Development.—According to Valentin, the fat first appears in the human embryo about the fourteenth week of intra-uterine life. At this period the fat-cells are insulated, but by the end of the fifth month they are collected into small groups. When first seen, they are also of comparatively small size. As already stated, the fœtal fat-cells contain a nucleus in their early condition, which afterwards disappears; but it is not certain that the nucleus precedes and gives rise to the cell.

It has been a question whether, when the fat undergoes absorption, the vesicles are themselves consumed along with their contents.* Dr. W. Hunter believed that they still remained after being emptied; he was led to this opinion by observing the condition of the cellular tissue in dropsical bodies from which the fat had disappeared, there being in such cases a marked difference in aspect between the parts of that tissue which had originally contained fat and those which had not, which difference he attributed to the persistence of the empty fat vesicles. Gurlt states that the fat-cells in emaciated animals are filled with serum.

* [In the rete of insects, during the larva state, exist numerous fat vesicles distended with oil, but which in the imago, are distinctly seen in the same position and contain no oil, which has apparently been displaced by a serous fluid.—J. L.]

SEROUS MEMBRANES.

The serous membranes are so named from the nature of the fluid with which their surface is moistened. They line cavities of the body which have no outlet, and the chief examples of them are, the peritoneum, the largest of all, lining the cavity of the abdomen; the two pleuræ and pericardium in the chest; the arachnoid membrane in the cranium and vertebral canal; and the tunica vaginalis surrounding each of the testicles within the scrotum.

Form and arrangement.—In all these cases the serous membrane has the form of a closed sac, one part of which is applied to the walls of the cavity which it lines, the *parietal* portion; whilst the other is reflected over the surface of the organ or organs contained in the cavity, and is therefore named the *reflected* or *visceral* portion of the membrane. Hence the viscera in such cavities are not contained within the sac of the serous membrane, but are really placed behind or outside of it; merely pushing inwards, as it were, the part of the membrane which immediately covers them, some organs receiving in this way a complete, and others but a partial and sometimes a very scanty investment.

In passing from one part to another, the membrane frequently forms folds which in general receive the appellation of ligaments, as, for example, the folds of peritoneum passing between the liver and the parietes of the abdomen, but which are sometimes designated by special names, as in the instances of the mesentery, mesocolon and omentum.

The peritoneum, in the female sex, is an exception to the rule that serous membranes are perfectly closed sacs, inasmuch as it has two openings by which the Fallopian tubes communicate with its cavity.

A serous membrane sometimes lines a fibrous membrane, as where the arachnoid lines the dura mater, or where the serous layer of the pericardium adheres to its outer or fibrous part. Such a combination is often named a *fibro-serous* membrane.

The inner surface of a serous membrane is free, smooth, and polished; and, as would occur with an empty bladder, the inner surface of one part of the sac is applied to the corresponding surface of some other part; a small quantity of fluid, usually not more than merely moistens the contiguous surfaces, being interposed. The parts situated in a cavity lined by serous membrane, can thus glide easily against its parietes or upon each other, and their motion is rendered smoother by the lubricating fluid.

The outer surface most commonly adheres to the parts which it lines or covers, the connexion being effected by means of cellular or areolar tissue, named therefore "subserous," which, when the mem-

brane is detached, gives to its outer and previously adherent surface a flocculent aspect. The degree of firmness of the connexion is very various: in some parts, the membrane can scarcely be separated; in others, its attachment is so lax as to permit of easy displacement. The latter is the case in the neighbourhood of the openings through which abdominal herniæ pass, and accordingly when such protrusions of the viscera happen to take place, they usually push the peritoneum before them in form of a hernial sac.

The visceral portion of the arachnoid membrane is in some measure an exception to the rule of the outer surface being everywhere adherent; for, in the greater part of its extent, it is thrown loosely round the parts which it covers, a few fine fibrous bands being the sole bond of connexion; and a quantity of serous fluid is interposed, especially in the vertebral canal and base of the cranium, between it and the pia mater, which is the membrane immediately investing the brain and spinal cord.

Structure and properties.—Serous membranes are thin and transparent, so that the colour of subjacent parts shines through them. They are tolerably strong, with a moderate degree of extensibility and elasticity. They consist of 1st, a simple layer of scaly epithelium, already described and figured (page 60, fig. 274), which, however, is ciliated on the serous membrane lining the ventricles of the brain, and on the part of the peritoneum which covers the fimbriated end of the Fallopian tubes; 2dly, next to the epithelium, and supporting it, an exceedingly fine lamella of *simple* or *homogeneous membrane*, named *basement membrane* by Todd and Bowman, who, as far as I know, were the first distinctly to point it out as a constituent of the serous membranes; and, 3dly, one or more layers of fine but dense cellular or areolar tissue. This consists, as usual, of bundles of white filaments mixed with elastic fibres: the former, when there are two or more layers, take a different direction in different planes; the latter unite into a network, and, in many serous membranes, as remarked by Henlé, are principally collected into a reticular layer at the surface of the strata of cellular tissue, or, to speak more precisely, immediately beneath the basement membrane. The constituent cellular tissue of the serous membrane, is of course continuous with the usually more lax *subserous cellular tissue* connecting the membrane to the subjacent parts.

Blood-vessels, ending in a capillary network with comparatively wide meshes, together with plexuses of lymphatic vessels, pervade the subserous tissue and the cellular tissue which forms part of the serous membrane, but do not penetrate its basement membrane or epithelium. Plexuses of fine nervous fibres have been described by several anatomists, in or immediately beneath the serous membranes of various regions; nevertheless, it would seem, that when in a healthy condition, these membranes possess little or no sensibility: they are altogether devoid of vital contractility.

Fluid.—The internal surface of serous cavities is moistened and lubricated with a transparent and nearly colourless fluid, which in health exists only in a very small quantity. This fluid, which is doubtless derived from the blood-vessels of the membrane, is commonly understood to be similar in constitution to the serum

of the blood, and such unquestionably is generally its nature when it accumulates in unusually large quantity, as in dropsical effusions, the chief or only difference being in its proportion of albumen, which is, for the most part, smaller than in blood-serum. But it was long since remarked by Hewson (and a similar opinion seems to have been held by Haller and Monro), that the fluid obtained from the serous cavities of recently killed animals coagulates spontaneously, and thus resembles the lymph of the lymphatic vessels, and, we may add, the liquor sanguinis or plasma of the blood, the coagulation being, of course, due to fibrin. Hewson found that the coagulability diminished as the quantity of the fluid increased. In confirmation of Hewson's statement, I may mention that I have always found the fluid obtained from the peritoneal cavity of rabbits to coagulate spontaneously in a greater or less degree. Hewson made his observations on the fluid of the peritoneum, pleura, and pericardium, in various animals, viz., bullocks, dogs, geese, and rabbits. The subject needs further examination, for we know that the small quantity of liquid which may generally be obtained from the human pericardium after death is not observed to contain a coagulum nor to coagulate on exposure.*

When a serous membrane is inflamed, it has a great tendency to throw out coagulable lymph (or fibrin) and serum, the two constituents of the blood plasma, the former chiefly adhering to the inner surface of the membrane, whilst the latter gathers in its cavity. The coagulable lymph spread over the surface, in form of a "false membrane," as it is called, or agglutinating the opposed surfaces of the serous sac and causing adhesion, becomes pervaded by blood-vessels, and in process of time converted into cellular tissue.

Breaches of continuity in these membranes are readily repaired, and the new-formed portion acquires all the characters of the original tissue.

* See Hewson's Works, published by the Sydenham Society, p. 157, with some important remarks in notes xviii. and lxviii, by the editor, Mr. Gulliver.

MUCOUS MEMBRANES.

THESE membranes, unlike the serous, line internal passages and other cavities which open on the surface of the body, as well as various recesses, sinuses, gland-ducts and receptacles of secretion, which open into such passages. They are habitually subject to the contact of foreign substances introduced into the body, such as air and aliment, or of various secreted or excreted matters, and hence their surface is coated over and protected by mucus, a fluid of a more consistent and tenacious character than that which moistens the serous membranes.

The mucous membranes of several different or even distant parts are continuous, and, with certain unimportant reservations, to be afterwards explained, they may all be reduced to two great divisions, namely, the *gastro-pulmonary* and the *genito-urinary*. The former covers the inside of the alimentary and air passages as well as the less considerable cavities communicating with them. It may be described as commencing at the edges of the lips and nostrils where it is continuous with the skin, and proceeding through the nose and mouth to the throat, whence it is continued throughout the whole length of the alimentary canal to the termination of the intestine, there again meeting the skin, and also along the windpipe and its numerous divisions as far as the air-cells of the lungs, to which it affords a lining. From the nose the membrane may be said to be prolonged into the lachrymal passages, extending up the nasal duct into the lachrymal sac and along the lachrymal canals until, under the name of the conjunctival membrane, it spreads over the fore part of the eyeball and inside of the eyelids, on the edges of which it encounters the skin. Other offsets from the nasal part of the membrane line the frontal, ethmoidal, sphenoidal, and maxillary sinuses, and from the upper part of the pharynx a prolongation extends on each side along the Eustachian tube to line that passage and the tympanum of the ear. Besides these there are offsets from the alimentary membrane to line the lachrymal, salivary, pancreatic, and biliary ducts and the gall-bladder. The *genito-urinary* membrane invests the inside of the urinary bladder and the whole track of the urine in both sexes, from the interior of the kidneys to the orifice of the urethra, also the seminal ducts and vesicles in the male, and the vagina, uterus, and Fallopian tubes in the female.

The mucous membranes lining the ducts of the mammary glands, being unconnected with either of the above-mentioned great tracts, have sometimes been enumerated as a third division, and the number might of course be multiplied, were we separately to reckon the membranes prolonged from the skin into the ducts of the numerous little glands which open on the surface of the body.

The mucous membranes are attached by one surface to the parts which they line or cover by means of areolar tissue, named "submucous," which differs greatly in quantity as well as in consistency in

different parts. The connexion is in some cases close and firm, as in the cavity of the nose and its adjoining sinuses; in other instances, especially in cavities subject to frequent variation in capacity, like the gullet and stomach, it is lax and allows of some degree of shifting of the connected surfaces. In such cases as the last-mentioned, the mucous membrane is accordingly thrown into folds, when the cavity is narrowed, by contraction of the exterior coat of the organ, and of course these folds, or *rugæ*, as they are named, are effaced by distension. But in certain parts the mucous membrane forms permanent folds, not capable of being thus effaced, which project conspicuously into the cavity which it lines. The best marked example of these is presented by the *valvulæ conniventes* seen in the small intestine. These, as is more fully described in the special anatomy of the intestines, are crescent-shaped duplicatures of the membrane, with connecting cellular tissue between their laminæ, which are placed transversely and follow one another at very short intervals along a great part of the intestinal tract. The chief purpose of the valvulæ conniventes is doubtless to increase the surface of the absorbing mucous membrane within the cavity, and it has also been supposed that they serve mechanically to delay the alimentary mass in its progress downwards. A mechanical office has also been assigned to a series of oblique folds of a similar permanent kind, though on a smaller scale, which exist within the cystic duct.

Physical properties.—In most situations the mucous membranes are nearly opaque or but slightly translucent. They possess no great degree of tenacity and but little elasticity, and hence are readily torn by a moderate force. As to colour, they cannot be said intrinsically to have any, and when perfectly deprived of blood they accordingly appear white or at most somewhat gray. The redness which they commonly exhibit during life, and retain in greater or less degree in various parts after death, is due to the blood contained in their vessels, although it is true that after decomposition has set in, the red matter of the blood, becoming dissolved, transudes through the coats of the vessels, and gives a general red tinge to the rest of the tissue. The degree of redness exhibited by the mucous membrane after death is greater in the fœtus and infant than in the adult. It is greater too in certain situations; thus, of the different parts of the alimentary canal, it is most marked in the stomach, pharynx, and rectum. Again, the intensity of the tint, as well as its extent, is influenced by circumstances accompanying or immediately preceding death. Thus the state of inflammation or the local application of stimuli to the membrane, such as irritant poisons, or even food, in the stomach, is apt to produce increased redness; and all the mucous membranes are liable to be congested with blood and suffused with redness when death is immediately preceded by obstruction to the circulation, as in cases of asphyxia, and in many diseases of the heart.

Structure.—A mucous membrane is composed of the corium and epithelium. The *epithelium* covers the surface and has already been described (p. 58). The membrane which remains after removal of the epithelium is named the *corium*, as in the analogous instance of the

true skin. The corium may be said to consist of a fibro-vascular layer, of variable thickness, bounded superficially or next the epithelium by an extremely fine transparent lamella, named *basement membrane* by Bowman, and *primary membrane*, *limitary membrane*, and *membrana propria* by others who have described it. It must be explained, however, that these two constituents of the corium cannot in all situations be separated from each other, nor indeed can the presence of both be proved by actual demonstration in all parts of the mucous membranes.

The *basement membrane* or *membrana propria* is best seen in parts where the mucous membrane is raised into villous processes, or where it forms secreting crypts or minute glandular recesses, such as those which abound in the stomach and intestinal canal. On tearing out a portion of the gastric or intestinal mucous membrane under the microscope, some of the tubular glands are here and there discovered which are tolerably well cleared from the surrounding tissue, and their parietes are seen to be formed of a thin pellucid film, which is detached from the adjoining fibro-vascular layer, the epithelium perhaps still remaining in the inside of the tube or having escaped, as the case may be. The fine film referred to is the basement membrane. It may by careful search be seen too on the part of the corium situated between the orifices of the glands, and on the villi, when the epithelium is detached, although it cannot be there separated from the vascular layer. In these parts it manifestly forms a superficial boundary to the corium, passing continuously over its eminences and into its recesses, defining its surface, and supporting the epithelium. Where villi and tubular glands are wanting, and where the mucous membrane, more simply arranged, presents an even surface, as in the tympanum and nasal sinuses, the actual presence of a fine film or basement membrane cannot be demonstrated. In such situations it may possible have originally existed as a constituent of the corium, and have been obliterated or rendered inconspicuous in consequence of subsequent modifications.

The basement membrane, as already said, forms the peripheral boundary of the corium; it is in immediate connexion with the epithelium, which it supports, and in the production of which it is supposed to have probably some share. By its under surface it more or less closely adjoins the fibro-vascular layer. The vessels of the latter advance close up to the basement membrane, but nowhere penetrate it; the delicate film of which it consists is indeed wholly extra-vascular. In respect of structure the membrane in question seems perfectly homogeneous, but marks resembling the nuclei of epithelium cells are sometimes seen disposed evenly over its surface, and some observers, considering these as forming an integrant part of the membrane, have looked on them as so many reproductive centres from which new epithelium particles are generated. Mr. Bowman, on the other hand, considers these objects as nuclei belonging to the undermost, and as it were nascent epithelium cells, which have remained adherent to the really simple basement membrane.

The *fibro-vascular layer* of the corium is composed of vessels, both sanguiferous and lymphatic, with fibres of cellular or areolar tissue;

the nerves also which belong to the mucous membrane are distributed in this part of its structure.

The vessels exist universally in mucous membranes, except in that which covers the anterior surface of the cornea; there the epithelium and basement membrane are present, but no vessels. The branches of the arteries and veins dividing in the submucous tissue send smaller branches into the corium, which at length form a network of capillaries in the fibro-vascular layer. This capillary network lies immediately beneath the basement membrane, advancing with that membrane into the villi and papillæ, to be presently described, and surrounding the tubes and other glandular recesses, into which it is hollowed. The lymphatics also form plexuses, the finest of which lie at the surface, probably just below the basement membrane; their arrangement generally, as well as in the villi, has been already described.

The fibres of cellular tissue which enter into the formation of the corium are arranged in interlacing bundles; but their amount is very different in different parts. In some situations, as in the gullet, bladder and vagina, the fibrous constituent is abundant, and extends throughout the whole thickness of the fibro-vascular layer, forming a continuous and tolerably compact web, and rendering the mucous membrane of those parts comparatively stout and tough. In the stomach and intestines, on the other hand, where the membrane is more complex, and at the same time weaker in structure, the cellular tissue is in small proportion; its principal bundles follow and support the blood-vessels, deserting, however, their finer and finest branches which lie next the basement membrane; and there exists, accordingly, next and for a little depth below this membrane, a stratum of the corium, in which very few if any filaments of cellular tissue are seen. In this superficial stratum, the sanguiferous capillaries and lymphatics are spread out amidst a soft granular matter, with a few corpuscles, mostly resembling cell-nuclei and granular cells. Here too, as well as deeper in the corium, a few bodies are seen having the appearance of fusiform cells. The villi present the same internal structure as this superficial stratum, and appear to be prolongations of it.

The free surface of the mucous membranes is in some parts plain, but in others is beset with little eminences, named papillæ and villi. The *papillæ* are best seen on the tongue; they are small processes of the corium, mostly of a conical and cylindrical figure, containing blood-vessels, and nerves, and covered with epithelium. Some are small and simple, others larger and compound or cleft into secondary papillæ. They serve various purposes; some of them no doubt minister to the senses of taste and touch, many appear to have chiefly a mechanical office, while others would seem intended to give greater extension to the surface of the corium for the production of a thick coating of epithelium. The *villi* are most frequently developed on the mucous coat of the small intestines. Being set close together like the pile or nap of cloth, they give to the parts of the membrane which they cover the aspect usually denominated "villous." They are in reality little elevations or processes of the superficial part of the

corium, covered with epithelium, and containing blood-vessels and lacteals, which are thus favourably disposed for absorbing nutrient matters from the intestine. The more detailed description of the papillæ and villi belongs to the special anatomy of the parts where they occur.

In some few portions of the mucous membrane, the surface is marked with fine ridges which intersect each other in a reticular manner, and thus inclose larger and smaller polygonal pits or recesses. This peculiar character of the surface of the membrane, which might be called "alveolar," is seen very distinctly in the gall-bladder, and on a finer scale in the vesiculæ seminales; still more minute alveolar recesses with intervening ridges may be discovered with a lens on the mucous membrane of the stomach.

Glands of mucous membranes.—Many, indeed most of the glands of the body, pour their secretions into the great passages lined by mucous membranes; but while this is true, there are certain small glands which may be said to belong to the membrane itself, inasmuch as they are found in numbers over large tracts of that membrane, and yield mucus, or special secretions known to be derived from particular portions of the membrane. Omitting local peculiarities, the glands referred to may be described as of three kinds, viz.:—

1. *Tubular follicles.*—These are minute tubes formed by recesses or inversions of the basement membrane, and lined with epithelium. They are usually placed perpendicularly to the surface, and often very close together, and they constitute the chief substance of the mucous membrane in those parts where they abound, its apparent thickness depending on the length of the tubes, which differs considerably in different regions. The tubes open by one end on the surface; the other end is closed, and is either simple or loculated. The tubular follicles are abundant in the stomach, in the small intestines, where they are comparatively short and known as the crypts of Lieberkühn, and in the large intestine. They exist also in considerable numbers in the mucous membrane of the uterus.

2. *Saccular follicles.*—These are small cavities of a rounded shape, found in various parts of the mucous membrane, but neither their structure, nor the nature of their secretion, has yet been sufficiently made out. Some of them are habitually closed, and only open occasionally to give issue to their secretions; others probably have constantly open orifices. Examples of the former variety are found in the agminated and solitary glands of the intestines.

3. *Small compound glands.*—Under this head are here comprehended minute but still true compound glands of the vesicular or racemose kind, with single branched ducts of various lengths, which open on different parts of the membrane. Numbers of these, yielding a mucous secretion, open into the mouth and windpipe. They have the appearance of small solid bodies, often of a flattened lenticular form, but varying much both in shape and size, and placed at different depths below the mucous membrane on which their ducts open. The glands of Brunner, which form a dense layer in the commencing part of the duodenum, are of this kind.

Nerves.—The mucous membranes are supplied with nerves, and endowed with sensibility; but the proportion of nerves which they receive, as well as the degree of sensibility which they possess, differs very greatly in different parts. As to the mode of distribution and termination of their nerves, there is nothing to be said beyond what has been already stated in treating of the nerves in general.

Secretion.—Mucus is a more or less viscid, transparent, or slightly turbid fluid, of variable consistency. It is somewhat heavier than water, though expectorated mucus is generally prevented from sinking in that liquid by entangled air-bubbles. Examined with the microscope, it is found to consist of a fluid, containing solid particles of various kinds, viz., 1. Epithelium particles detached by desquamation; 2. Mucous corpuscles, which are bodies resembling much the pale corpuscles of the blood; 3. Nucleated cells, with more or less ample envelope, and apparently in a state of transition from the condition of mucous corpuscles to that of epithelium particles. The viscidity of mucus depends on the liquid part, which contains in solution a peculiar substance, named by the chemists *mucin.* This ingredient is precipitated and the mucus rendered turbid by the addition of water or a weak acid, but it may be partly redissolved in an excess of water, and completely so in a strong acid. This mucin is soluble in alkalies, and its acid solutions are not precipitated by ferrocyanide of potassium. Little can, of course, be expected from a chemical analysis of a heterogeneous and inseparable mixture of solid particles with a liquid solution, such as we find in mucus, which is, moreover, subject to differences of quality according to the part of the mucous membrane whence it is derived. Examined thus in the gross, however, the nasal mucus has been found to yield water, mucin, alcohol-extract with alkaline lactates, water-extract with traces of albumen and a phosphate, chlorides of sodium and potassium, and soda. Fat has been obtained by analysis of pulmonary mucus, reputed healthy.

Regeneration.—The reparatory process is active in the mucous membranes. Breaches of continuity occasioned by sloughing, ulceration, or other causes, readily heal. The steps of the process have been examined with most care in the healing of ulcers of the large intestine, and in such cases it has been found that the resulting cicatrix becomes covered with epithelium, but that the tubular follicles are not reproduced.

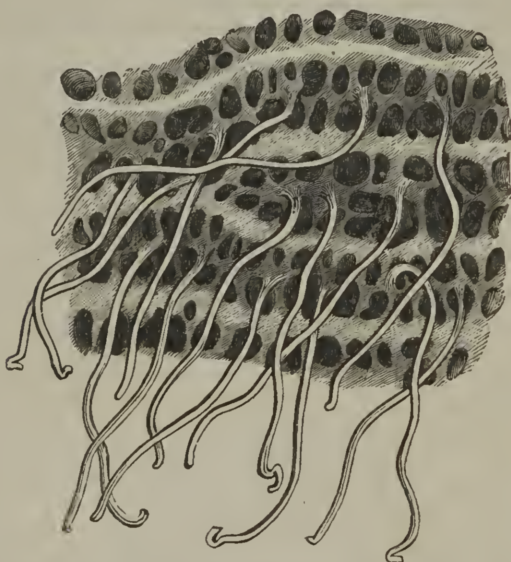
THE SKIN.

The skin consists of the cutis vera or corium and the cuticle or epidermis.

The *epidermis, cuticle,* or *scarf skin,* belongs to the class of epithelial structures, the general nature of which has been already considered. It forms a protective covering over every part of the true skin, and is itself quite insensible and non-vascular. The thickness of the cuticle varies in different parts of the surface, measuring in some not more than $\frac{1}{240}$th, and in others from $\frac{1}{24}$th to $\frac{1}{12}$th of an inch. It is thickest in the palms of the hands and soles of the feet, where the skin is much exposed to pressure, and it is not improbable that this may serve to stimulate the subjacent true skin to a more active formation of epidermis; but the difference does not depend solely on external causes, for it is well marked even in the fœtus.

Structure.—The cuticle is made up of flattened cells agglutinated together in many irregular layers. These cells arise in a blastema,

[Fig. 286.



Under surface of the cuticle, detached by maceration from the palm; showing the double rows of depressions in which the papillæ have been lodged, with the hard epithelium lining the sudoriferous ducts in their course through the cutis. Some of these are contorted at the end, where they have entered the sweat-gland.—Magnified 30 diameters.—Todd and Bowman.]

which is poured out on the surface of the true skin. They are at first round, and contain nuclei with soft and moist contents, but, by successive formations beneath them, they are gradually pushed to the free

surface, and in their progress become flattened into thin irregular scales, for the most part lose their nuclei, and are at last thrown off by desquamation. As the cells change their form, they undergo chemical and physical changes in the nature of their contents; for those in the deeper layers contain a soft, opaque, granular matter, soluble as well as their envelope in acetic acid, whilst the superficial ones are transparent, dry, and firm, and are not affected by that acid. It would seem as if their contents were converted into a horny matter, and that a portion of this substance is employed to cement them together. The more firm and transparent superficial part of the epidermis may be separated from the deeper, softer, more opaque, and recently formed part, which constitutes what is called the *rete mucosum*.

Many of the cells of the cuticle contain pigment, and often give the membrane more or less of a tawny colour, even in the white races of mankind; the blackness of the skin in the negro depends entirely on the cuticle. The pigment is contained principally in the cells of the deep layer or rete mucosum, and appears to fade as they approach the surface, but even the superficial part possesses a certain degree of colour. More special details respecting the pigment have been already given (page 69).

The under or attached surface [fig. 286] of the cuticle is moulded on the adjoining surface of the corium, and, when separated by maceration or putrefaction, presents impressions corresponding exactly with the papillary or other eminences, and the furrows or depressions of the true skin; the more prominent inequalities of the latter are marked also on the outer surface of the cuticle, but less accurately. Fine tubular prolongations of the cuticle sink down into the ducts of the sweat glands, and are often partially drawn out from their recesses when the cuticle is detached, appearing then like threads proceeding from its under surface.

Chemical composition.—The cuticle consists principally of a substance peculiar to the epithelial and horny tissues, and named *keratin*. This horny matter is insoluble in water at ordinary temperatures, and insoluble in alcohol. It is soluble in the caustic alkalies. In composition, it is analogous to the albuminoid principles, but with a somewhat larger proportion of oxygen; like these, it contains sulphur. Besides keratin, the epidermis yields, on analysis, a small amount of fat, with salts, and traces of the oxides of iron and manganese. The tissue of the cuticle readily imbibes water, by which it is rendered soft, thick, and opaque, but it speedily dries again, and recovers its usual characters.

The *true skin*, *cutis vera*, *derma*, or *corium*, is a sentient and vascular texture. It is covered and defended, as already explained, by the insensible and non-vascular cuticle, and is attached to the parts beneath by a layer of cellular tissue, named "subcutaneous," which, excepting in a few parts, contains fat, and has therefore been called also the "panniculus adiposus." The connexion is in many parts loose and movable, in others close and firm, as in the palmar surface of the hand and the sole of the foot, where the skin is fixed to the subjacent fascia by numerous stout fibrous bands, the space between being filled with a firm padding of fat. In some regions of the body the skin is moved by muscular fibres, which, as in the case of the orbicular mus-

cle of the mouth, may be unconnected to fixed parts, or may be attached beneath to bones or fasciæ, like the other cutaneous muscles of the face and neck, and the short palmar muscle of the hand.

Structure.—The corium consists of a *fibro-vascular layer*, which is supposed to be bounded at the surface next the cuticle by a fine homogeneous *basement membrane* or *membrana propria*, like the corresponding part of the mucous membrane. No such superficial film can, it is true, be raised from the corium, but from its distinct presence in small gland-ducts which are continuous with the corium, and from the well-defined outline presented by the papillary eminences on its surface, it is presumed that a limitary membrane of this sort ought to be reckoned as an element of the corium, although, as in the analogous case of the mucous membrane, it cannot be shown to exist over the whole surface. The *fibro-vascular* part is made up of an exceedingly strong and tough framework of interlaced fibres, with blood-vessels and lymphatics. The fibres are chiefly of the white variety, such as constitute the chief part of the fibrous and areolar tissues, and are arranged in stout interlacing bundles, except at and near the surface, where the texture of the corium becomes very fine. With these are mixed yellow or elastic fibres, which vary in amount in different parts, but in all cases are present in much smaller proportion than the former kind. The interlacement becomes much closer and finer towards the free surface of the corium, and there the fibres can be discovered only by teasing out the tissue. Towards the attached surface, on the other hand, the texture becomes much more open, with larger and larger meshes, in which clumps of fat and the small sudatory glands are lodged, and thus the fibrous part of the skin becoming more and more lax and more mixed with fat, blends gradually with the subcutaneous areolar tissue to which it is allied in elementary constitution.

In consequence of this gradual transition of the corium into the subjacent tissue, its thickness cannot be assigned with perfect precision. It is generally said to measure from a quarter of a line or less to nearly a line and a half. As a general rule, it is thicker on the posterior aspect of the head, neck, and trunk, than in front; and thicker on the outer than on the inner side of the limbs. The corium, as well as the cuticle, is remarkably thick on the soles of the feet and palms of the hands. The skin of the female is thinner than that of the male.

The free surface of the corium is marked in various places with larger or smaller furrows, which also affect the superjacent cuticle. The larger of them are seen opposite the flexures of the joints, as those so well known in the palm of the hand and at the joints of the fingers. The finer furrows intersect each other at various angles, and may be seen almost all over the surface: they are very conspicuous on the back of the hands. These furrows are not merely the consequence of the frequent folding of the skin by the action of muscles or the bending of the joints, for they exist in the fœtus. The wrinkles of old persons are of a different nature, and are caused by the wasting of the soft parts which the skin covers. Fine curvilinear ridges, with intervening furrows, mark the skin of the palm and sole; these are caused by ranges of the papillæ, to be immediately described.

Papillæ.—The free surface of the corium is beset with small eminences thus named, which seem chiefly intended to contribute to the perfection of the skin as an organ of touch, seeing that they are highly developed where the sense of touch is exquisite, and vice versâ. They serve also to extend the surface for the production of the cuticular tissue, and hence are large-sized and numerous under the nail. The papillæ are large and in close array on the palm and palmar surface of the fingers, and on the corresponding parts of the foot (fig. 287). There they are ranged in lines, forming the curvilinear ridges seen when the skin is still covered with its thick epidermis. They are of

[Fig. 287.

Fig. 287. Papillæ of the palm, the cuticle being detached. Magnified 35 diameters.—Todd and Bowman.

Fig. 288.

Fig. 288. Surface of the skin of the palm, showing the ridges, furrows, cross grooves, and orifices of the sweat-ducts. The scaly texture of the cuticle is indicated by the irregular lines on the surface. Magnified 20 diam.—Todd and Bowman.]

a conical figure, rounded or blunt at the top, and are received into corresponding pits on the under surface of the cuticle. They measure on the hand from $\frac{1}{200}$th to $\frac{1}{100}$th of an inch in height. In the ridges, the large papillæ are placed sometimes in single but more commonly in double rows, with smaller ones between them, that is, also on the ridges, for there are none in the intervening grooves. These ridges are marked at short and tolerably regular intervals with notches, or short transverse furrows, in each of which, about its middle, is the minute funnel-shaped orifice of the duct of a sweat-gland (fig. 288). Fine blood-vessels enter the papillæ, forming either simple capillary loops in each, or dividing into two or more capillary branches, according to the size of the papilla, which turn round in form of loops and return to the veins. Filaments of nerves are also to be discovered ascending into the papillæ, but their mode of termination is doubtful, and what is known on the subject will be stated hereafter. In other parts of the skin endowed with less sensibility, the papillæ are smaller, shorter, fewer in number, and irregularly scattered. In parts where they are naturally small, they often become enlarged by chronic inflammation round the margin of sores and ulcers of long standing, and are then much more conspicuous.

Blood-vessels and lymphatics.—The blood-vessels divide into branches in the subcutaneous tissue, and, as they enter the skin, supply capillary plexuses to the fat clumps, sweat glands, and hair fol-

licles. They divide and anastomose still further as they approach the surface, and at length on reaching it, form a dense network of capillaries, with rounded polygonal meshes, as previously represented in figure 232. Fine branches are sent into the papillæ, as already mentioned. The lymphatics are abundant in some parts of the skin, as on the scrotum and round the nipple; whether they are equally so in all parts may be doubted. They form networks, which become finer as they approach the surface, and communicate underneath with straight vessels, and these, after a longer or a shorter course, join larger ones, or enter lymphatic glands.

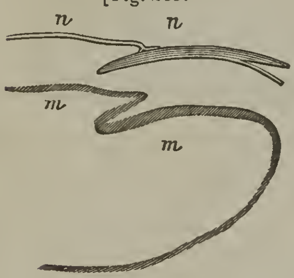
Nerves.—Nerves are supplied in very different proportions to different regions of the skin, and according to the degree of sensibility. Their mode of termination has been already considered.

Chemical composition.—The corium being composed chiefly of white fibrous tissue, has a corresponding chemical composition. It is, accordingly, in a great measure, resolved into gelatin by boiling, and hence, also, its conversion into leather by the tanning process.

Nails and *Hairs.*—The nails and hairs are growths of the epidermis, agreeing essentially in nature with that membrane; like the epidermis, they are destitute of vessels and nerves and separable from the cutis.

Nails.—The posterior part of the nail [fig. 289], which is concealed in a groove of the skin, is named its "root," the uncovered part is the "body," which terminates in front by the "free edge." A small portion of the nail near the root, named from its shape the *lunula*, is whiter than the rest. This appearance is due partly to some degree of opacity of the substance of the nail at this point and partly to the skin beneath being less vascular than in front.

[Fig. 289.



Section of the skin on the end of the finger:—The cuticle and nail, *n*, detached from the cutis and matrix, *m*.—Todd and Bowman.]

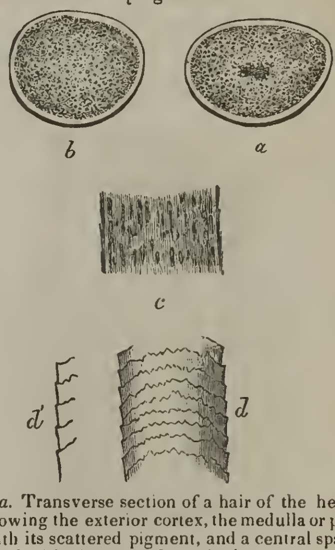
The part of the corium to which the nail is attached, and by which in fact it is secreted or generated, is named the matrix [fig. 289, *m*]. This portion of the skin is highly vascular and thickly covered with large vascular papillæ. Posteriorly the matrix is bounded by a crescentic groove or fold, deep in the middle but getting shallower at the sides, which lodges the root of the nail. The small lighter coloured part of the matrix next the groove and corresponding with the lunula of the nail, is covered with papillæ having no regular arrangement, but the whole remaining surface of the matrix situated in front of this, and supporting the body of the nail, is marked with longitudinal and very slightly diverging ridges formed by rows of papillæ. The cuticle, advancing from the back of the finger, becomes attached to the upper surface of the nail near its posterior edge, that is, all round the margin of the groove in which the nail is lodged; in front the cuticle of the point of the finger becomes continuous with the under surface of the nail a little way behind its free edge.

The substance of the nail, like that of the cuticle, is made up of scales derived from flattened cells. The oldest and most superficial of these are the broadest and hardest, but at the same time very thin and irregular, and so intimately and confusedly connected together that their respective limits are scarcely discernible. But the youngest cells, which are those situated at the root and under surface, are softer, and of a rounded or polygonal shape, and still retain their nuclei. In chemical composition the nails resemble epidermis.

The growth of the nail is effected by a constant generation of cells at the root and under surface. Each successive series of these cells being followed and pushed from their original place by others, lose their nuclei, and become flattened into dry, hard, and inseparably coherent scales. By the addition of new cells at the posterior edge the nail is made to advance, and by the apposition of similar particles to its under surface it is maintained of due thickness. The nail being thus merely an exuberant part of the epidermis, the question whether that membrane is continued underneath it loses its significance. When a nail is thrown off by suppuration or pulled away by violence, a new one is produced in its place, provided the matrix remains.

Hairs.—A hair consists of the root, which is fixed in the skin, the shaft or stem, and the point. The *stem* is generally cylindrical, but often more or less flattened, sometimes it is grooved along one side, and therefore reniform in a cross section; when the hair is entire it becomes gradually smaller towards the point. The length and thickness vary greatly in different individuals and races of mankind as well as in different regions of the body. Light coloured hair is usually finer than black.

[Fig. 290.



a. Transverse section of a hair of the head, showing the exterior cortex, the medulla or pith with its scattered pigment, and a central space filled with pigment. *b.* A similar section of a hair, at a point where no aggregation of pigment in the axis exists. *c.* Longitudinal section, without a central cavity, showing the imbrication of the cortex, and the arrangement of the pigment in the fibrous part. *d.* Surface, showing the sinuous transverse lines formed by the edges of the cortical scales. *d'.* A portion of the margin, showing their imbrication. Magn. 150 diam.—Todd and Bowman.]

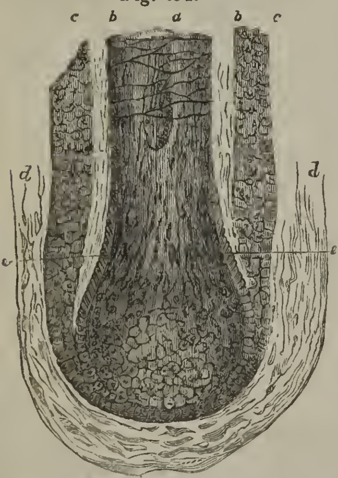
The stem is covered with a coating of finely imbricated scales, the projecting serrated edges of which give rise to a series of fine waved transverse lines, which may be seen with the microscope on the surface of the hair. Within this scaly covering is a fibrous substance, which in all cases constitutes the chief part and often the whole of the stem; but in many hairs the axis is occupied by a substance of a different nature, called the medulla or pith, [fig. 290,] for which reason the surrounding fibrous part is often named "cortical," although this term is more properly applied to the superficial coating

of scales abovementioned. The fibrous substance is translucent, with short longitudinal opaque streaks of darker colour intermixed; it is made up of straight, rigid, longitudinal fibres, which, when separated, are found to be flattened, broad in the middle, and pointed at each end, with dark and rough edges.*

These fibres, as will be afterwards explained, are derived from elongated and metamorphosed cells; they are mostly transparent or marked with only a few dark specks. The coloured streaks in the fibrous substance are caused by collections of pigment or elongated cell-nuclei.

The medulla, or pith, as already remarked, does not exist in all hairs. It is wanting in the fine hairs over the general surface of the body, and is not commonly met with in those of the head. When present it occupies the centre of the shaft and ceases towards the point. It is more opaque and deeper coloured than the fibrous part; in the white hairs of quadrupeds it is opaque and white. It seems to be composed of little clumps or clusters of minute particles, some resembling pigment granules, others like very fine fat granules, which form a continuous dark mass along the middle of the stem, or are interrupted at parts for a greater or less extent. In the latter case, the axis of the stem at the interruptions may be fibrous like the surrounding parts, or these intervals may be occupied by a clear, colourless matter; and, according to Henlé, some hairs present the appearance of a sort of canal running along the axis, and filled in certain parts with opaque granular matter, and in others with a homogeneous transparent substance.

Fig. 291.



Magnified view of the root of the hair (after Kohlräusch). *a.* Stem or shaft of hair cut across. *b.* Inner, and *c* outer layer of the epidermic lining of the hair follicle, called also the root-sheath. *d.* Dermic or external coat of the hair follicle, shown in part. *e.* Imbricated scales about to form a cortical layer on the surface of the hair.

The *root* of the hair is lighter in colour and softer than the stem; it swells out at its lower end into a bulbous enlargement or knob, and is received into a recess of the skin named the *hair follicle*, which, when the hair is of considerable size, reaches down into the subcutaneous fat. The follicle, which receives near its mouth the opening ducts of one or more sebaceous glands, is somewhat dilated at the bottom, to correspond with the bulging of the root; it consists of an outer coat, continuous with the corium (fig. 291, *d*, *d*), and an epidermic lining (*b*, *c*), continuous with the cuticle. The outer or dermic coat is thin, but firm; it is made

* The breadth of these fibres, measured at the middle, is stated by Henlé at $\frac{1}{4400}$th of an inch, but Bidder affirms that, on macerating a hair in hydrochloric acid, it may be split into fibres a great deal smaller than this.

up of fibres like those of the corium, and is well supplied with blood-vessels. The epidermic lining adheres closely to the root of the hair, and commonly separates, in great part, from the follicle, and abides by the hair, when the latter is pulled out; hence it is sometimes named the "root-sheath." It consists of an outer, softer, and more opaque stratum (fig. 291, *c*, *c*) next the dermic coat of the follicle, and an internal more transparent layer (*b*, *b*) next the hair. The former corresponds with the deeper and more recent layer of the cuticle in general, and contains blastema, with nuclei, and growing cells; the latter represents the superficial and more mature part of the cuticle, and consists of oblong flattened cells, many of them with nuclei, and lying two or three deep. This innermost layer, when detached, exhibits impressions of cross lines on its surface, corresponding with those of the imbricated scaly coating of the hair, next which it lies. Between the two layers of the cuticular lining here described is interposed a lamina of fenestrated membrane, transparent and homogeneous, and perforated with round, oval, and irregular-shaped holes.*

The soft bulbous enlargement of the root of the hair is attached by its base to the bottom of the follicle, and at the circumference of this attached part it is continuous with the epidermic lining; at the bottom of the follicle it, in fact, takes the place of the epidermis, of which it is a growth or extension, and this part of the follicle is the true matrix of the hair, being, in reality, a part of the corium (though sunk below the general surface), which supplies material for the production of the hair. This productive part of the follicle is, accordingly, remarkably vascular, and, in the large tactile hairs on the snout of the seal, is raised in form of a conical papilla or pulp, which fits into a corresponding excavation of the hair root, but there is no such marked elevation in the bottom of the human hair follicle. Nervous branches of considerable size enter the follicles of the large tactile hairs referred to, and are probably distributed to the papillæ, though, of course, not to the substance of the hair; the pain occasioned by pulling the hair would seem to suggest that the human hair follicles are not unprovided with nerves.

Growth of hair.—On the surface of the vascular matrix, at the bottom of the follicle, blastema is thrown out, in which nucleated cells arise. The cells, many of which previously get filled with pigment, for the most part lengthen out into the flattened fibres and coloured streaks which compose the fibrous part of the hair; their nuclei, at first, also lengthen in the same manner, but, at last, mostly become indistinct. The cells next the circumference expand into the scales which form the imbricated cortical layer (fig. 291, *e*, *e*). The medulla, where it exists, is formed by the cells nearest the centre; these retain

* The fenestrated membrane was first pointed out in the hair-sheath by Henlé, who described it as lying next to the hair; but Mr. Huxley has shown that a stratum of nucleated cells intervenes between it and the surface of the hair. (Med. Gaz. Nov. 1845, p. 1340.) Kohlräusch conceived that the appearance of a fenestrated membrane was fallacious, and was occasioned by laceration of the inner transparent layer of oblong cells. This inner layer may, it is true, be readily lacerated, but I have nevertheless satisfied myself of the independent existence of a fenestrated membrane, interposed, as Mr. Huxley describes, between the outer and inner layers of the cuticular lining of the hair-follicle,—however difficult it may be to reconcile this fact with the known constitution of the cuticle in general.

their primitive figure longer than the rest; their cavities coalesce together by destruction of their mutually adherent parietes, whilst collections of pigment granules make their appearance in them and around their nuclei, forming an opaque mass, which occupies the axis of the hair.

The substance of the hair, like that of the cuticle, is quite extravascular, but, like that structure also, it is organized and subject to internal organic changes. Thus, in the progress of its growth, the cells change their figure, and acquire greater consistency. In consequence of their elongation, the hair, bulbous at the commencement, becomes reduced in diameter and cylindrical above. But it cannot be said to what precise distance from the root organic changes may extend. Some have imagined that the hairs are slowly permeated by a fluid, from the root to the point, but this has not been proved. The sudden change of the colour of the hair from dark to gray, which sometimes happens, has never been satisfactorily explained.

Development of the hair in the fœtus.—According to Valentin, the rudiments of the hairs appear at the end of the third or beginning of the fourth month of intra-uterine life, as little black specks beneath the cuticle. From the investigations of Gustavus Simon, on the origin of the hairs in the fœtal pig, it would seem that the follicle is the first part to appear. This is formed of a saccular or cylindrical recess of the skin, lined with epidermis, but whether it be at first also closed by that membrane is uncertain. Most of these follicles contain dark-coloured pigment cells on their parietes, and a larger collection of them at the bottom, which corresponds to the knob or bulbous part of the future hair; but in some this part consists of colourless cells. The diminutive hair then appears, its shaft being disproportionately small. As it lengthens it becomes bent on itself like a whip, and the doubled part first protrudes from the follicle. The first hairs produced in the human fœtus constitute the lanugo; their eruption takes place about the fifth month, but many of them are shed before birth, and are found floating in the liquor amnii.

Reproduction.—When a hair is pulled out a new one grows in its place, provided the follicle remains entire. The steps of this process have been experimentally studied by Heusinger, on the large hairs situated on the lips of the dog. He found that a new hair appeared above the surface in a few days after the evulsion of the old one, and attained its full size in about three weeks. Blood was at first effused into the follicle, but was subsequently absorbed, and after some inflammation and swelling of the coats of the follicle, which soon subsided, the new hair commenced as a black spot on the pulp at the bottom; it then lengthened out and appeared above the surface. When quadrupeds shed and renew their hair, the new hair is produced in the old follicle.

Distribution and arrangement.—Hairs are found on all parts of the skin except the palms of the hands and soles of the feet, the dorsal surface of the third phalanges of the fingers and toes, the upper eyelids, the glans, and the inner surface of the prepuce. They are for the most part grouped together, and not placed at equal distances. Except those of the eyelashes, which are implanted perpendicularly to the surface, they have usually a slanting direction, which is wonderfully constant in the same parts.*

Chemical nature.—The chemical composition of hair has been investigated principally by Vauquelin, Scherer, and Van Laer. When treated with boiling alcohol, and with ether, it yields a certain amount of oily fat, consisting of margarin, margaric acid, and olein, which is red or dark-coloured, according to the tint of the hair. The animal matter of the hair thus freed from fat, is supposed

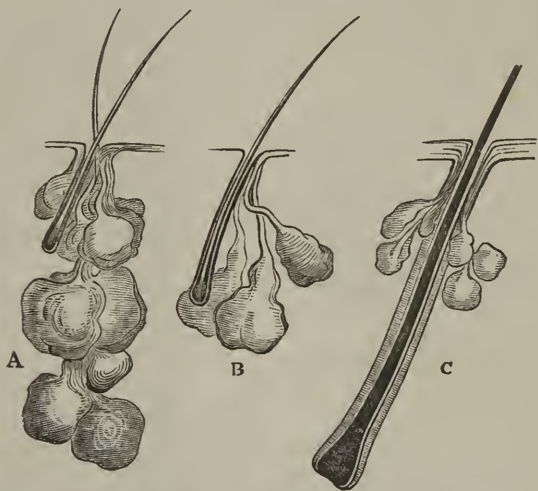
* The direction of the hairs in different parts, is well seen in the new-born infant. As so observed, it has been described and represented in figures, by Eschericht. Muller's Archiv., 1837.

to consist of a substance yielding gelatin, and a protein compound containing a large proportion of sulphur. It is insoluble in water, unless by long boiling under pressure, by which it is reduced into a viscid mass. It readily and completely dissolves in caustic alkalies. By calcination hair yields from 1 to 1½ per cent of ashes, which consist of the following ingredients, viz., peroxide of iron, and according to Vauquelin, traces of manganese, silica, chlorides of sodium and potassium, sulphates of lime and magnesia, and phosphate of lime. With the exception of the bones and teeth, no tissue of the body withstands decay after death so long as the hair, and hence it is often found preserved in sepulchres, when nothing else remains but the skeleton.

Glands of the skin.—These are of two kinds, the sebaceous, which yield a fatty secretion, and the sweat glands.

The sebaceous glands [fig. 292,] pour out their secretion at the roots of the hairs, for, with a very few isolated exceptions, they open into

[Fig. 292.



Sebaceous glands, showing their size and relation to the hair follicles:—A and B from the nose; C from the beard. In the latter the cutis sends down an investment of the hair follicle.—Magnified 18 diameters.—Todd and Bowman.]

the hair follicles, and are found wherever there are hairs. Each has a small duct, which opens at a short distance within the mouth of the hair follicle, and, by its other end, leads to a cluster of small rounded secreting saccules, which, as well as the duct, are lined by epithelium, and usually charged with the fatty secretion, mixed with detached epithelium particles. The number of saccular recesses connected with the duct usually varies from four or five to twenty; it may be reduced to two or three, in very small glands, or even to one, but this is rare. These glands are lodged in the substance of the corium. Several may open into the same hair follicle, surrounding it on all sides, and their size is not regulated by the magnitude of the hair. Thus, some of the largest are connected with the fine downy hairs on the alæ of the nose and other parts of the face, and there they often become unduly charged with pent-up secretion.*

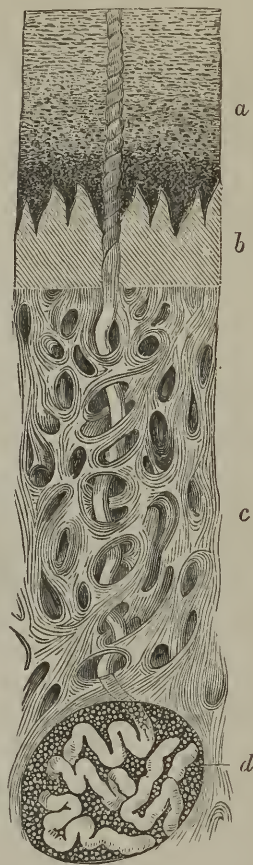
* A few years ago it was discovered by Dr. Gustavus Simon, that the sebaceous and hair follicles were infested by a worm, which he has described and delineated in Müller's

The sudoriferous glands or *sweat glands.*—These are seated on the under surface of the corium, and at variable depths in the subcutaneous

[Fig. 293.

Sweat-gland and the commencement of its duct:—*a.* Venous radicles on the wall of the cell in which the gland rests. This vein anastomoses with others in the vicinity. *b.* Capillaries of the gland separately represented, arising from their arteries, which also anastomose. The blood-vessels are all situated on the outside or deep surface of the tube, in contact with the basement membrane.—Magnified 35 diameters.—Todd and Bowman.]

[Fig. 294.



Vertical section of the sole:—*a.* Cuticle; the deep layers (rete mucosum) more coloured than the upper, and their particles rounded; the superficial layers more and more scaly. *b.* Papillary structure. *c.* Cutis. *d.* Sweat-gland, lying in a cavity on the deep surface of the skin, and imbedded in globules of fat. Its duct is seen passing to the surface. Magnified 40 diameters.—Todd and Bowman.]

adipose tissue. They have the appearance of small round reddish bodies, each of which, when examined with the microscope, is found to consist of a fine tube, coiled up into a ball (though sometimes forming an irregular or flattened figure), from which the tube is continued, as the duct of the gland, upwards through the true skin and cuticle, and opens on the surface by a slightly widened orifice. The duct, as it passes through the epidermis, is twisted like a corkscrew, that is, in parts where the epidermis is sufficiently thick to give room for this; lower down it is but slightly curved (fig. 294). Sometimes the duct is formed of two coiled-up branches, which join at a short distance from the gland. The tube, both in the gland and where it forms the excretory duct, consists of an outer coat, continuous with

Archiv. for 1842. Since then, further interesting details respecting this curious parasite, with observations on its development, have been contributed by Mr. E. Wilson. Phil. Trans. 1844.

the corium, and reaching no higher than the surface of the true skin, and an epithelial lining, continuous with the epidermis, which alone forms the twisted part of the duct. The outer or dermic coat is formed by simple or basement membrane, strengthened by fine fibres of cellular tissue. On carefully detaching the cuticle from the true skin, after its connexion has been loosened by putrefaction, it usually happens that the cuticular linings of the sweat ducts get separated from their interior to a certain depth, and are drawn out in form of short threads attached to the under surface of the epidermis. Each little sweat gland is supplied with a dense cluster of capillary blood-vessels.

Sweat glands exist in all regions of the skin, and attempts have been made to determine their relative amount in different parts, for they are not equally abundant everywhere; but while it is easy to count their numbers in a given space on the palm and sole, the numerical proportion assigned to them in most other regions must be taken with considerable allowance. According to Krause, nearly 2,800 open on a square inch of the palm of the hand, and somewhat fewer on an equal extent of the sole of the foot. He assigns rather more than half this number to a square inch on the back of the hand, and not quite so many to an equal portion of surface on the forehead, and the front and sides of the neck; then come the breast, abdomen, and fore-arm, where he reckons about 1,100 to the inch, and lastly, the lower limbs and the back part of the neck and trunk, on which the number in the same space is not more than from 400 to 600.

The size of the sweat glands also varies. According to the observer last named, the average diameter of the round-shaped ones is about one-sixth of a line; but in some parts they are larger than this, as for example, in the groin, but especially in the axilla. In this last situation Krause found the greater number to measure from one-third of a line to a line, and some nearly two lines in diameter.

Functions and vital properties of the skin.—The skin forms a general external tegument to the body, defining the surface, and coming into relation with foreign matters externally, as the mucous membrane, with which it is continuous and in many respects analogous, does internally. It is also a vast emunctory, by which a large amount of fluid is eliminated from the system, in this also resembling certain parts of the mucous membrane. Under certain conditions, moreover, it performs the office of an absorbing surface, but this function is greatly restricted by the epidermis. Throughout its whole extent the skin is endowed with *tactile sensibility*, but in very different degrees in different parts. On the skin of the palm and fingers, which is largely supplied with nerves and furnished with numerous prominent papillæ, the sense attains a high degree of acuteness; and this endowment, together with other conformable arrangements and adaptations, invests the human hand with the character of a special organ of touch. A certain, though low degree of vital contractility, seems also to belong to the skin. This shows itself in the general shrinking of the skin caused by naked exposure to cold and by certain mental emotions, and producing the state of the surface named "cutis anserina," in consequence of the little eminences becoming more prominent. The erection of the nipple is probably also due to contractility. The scrotum, as is well known, becomes obviously shrunk and corrugated by the application of cold or mechanical irritation to its surface; but in this case the contraction takes place in the subcutaneous tissue, and the skin is puckered. It has been supposed by Müller and others, that the contraction of the cutaneous and subcutaneous tissue, in the different cases mentioned, is caused by contractile fibres, not differing in structure from the fibres of ordinary cellular tissue. In opposition to this opinion, however, it has been clearly proved that the subcutaneous tissue of the scrotum contains true muscular fibres of the plain variety, as already mentioned; at the same time, it has not yet been determined whether similar muscular fibres are in any proportion intermixed with those which constitute the framework of the corium.

Reproduction of skin.—When a considerable portion of the skin is lost, the breach is repaired partly by a drawing inwards of the adjoining skin, and partly by the formation of a dense tissue, less vascular than the natural corium, and in which, so far as I know, hairs and glands are not reproduced, so that some deny that the cutaneous tissue is regenerated. Still the new part becomes covered with epidermis, and its substance sufficiently resembles that of the corium to warrant its being considered as cutaneous tissue regenerated in a simple form. I may add, that in small breaches of continuity, from cuts inflicted in early life, the uniting part sometimes acquires furrows similar to those of the adjoining surface.

SECRETING GLANDS.

The term gland has been applied to various objects, differing widely from each other in nature and office, but the organs of which it is proposed to consider generally the structure, in the present chapter, are those devoted to the function of secretion.

By secretion is meant a process in an organized body, by which various matters, derived from the solids or fluids of the organism, are collected and discharged at particular parts, in order to be further employed for special purposes in the economy, or to be simply eliminated as redundant material or waste products. Of the former case, the saliva and gastric juice, and of the latter, which by way of distinction is often called "excretion," the urine and sweat may be taken as examples.

Secretion is very closely allied to nutrition. In the one process, as in the other, materials are selected from the general mass of blood and appropriated by solid textures; but in the function of nutrition or assimilation, the appropriated matter is destined, for a time, to constitute part of the texture or organ, whereas in secretion it is immediately discharged at a free surface. The resemblance is most striking in those cases in which the waste particles of the texture nourished are shed or cast off at its surface, as in the cuticle and other epithelial tissues. It has thus been common, with physiological writers, to designate the selection and deposition of material which takes place in nutrition by the term "nutritive secretion," whilst the function of which we have here to consider generally the organs, is named simply "secretion," or sometimes, when necessary for the sake of distinction, "excretive secretion."

In man, and in animals which possess a circulating blood, that fluid is the source whence the constituents of the secretions are proximately derived; and it is further ascertained, that some secreted matters exist ready formed in the blood, and require only to be *selected* and separated from the general mass, whilst others would seem to be *prepared* from the materials of the blood, by the agency of the secreting organ. Among the secreted substances belonging to the former category, several, such as water, common salt, and albumen, are primary constituents of the blood, but others, as urea, uric acid, and certain salts, are the result of changes, both formative and destructive, which take place in the solid textures and in the blood itself, in the general process of nutrition. Again, as regards those ingredients of the secretions which are prepared or elaborated in the secretory apparatus, it is to be observed, that they may undergo changes in organic form, as well as in chemical composition. Evidence of this is afforded by the solid corpuscles found in many secretions, as well as by the seminal cells and spermatozoa produced in the testicle.

In considering, *à priori*, the structural adaptations required in a secreting apparatus, one important provision which immediately sug-

gests itself is, that the blood-vessels should approach some free surface from which the secretion may be poured out. It is not, however, necessary that the vessels should open on the secreting surface, seeing that their coats, as well as the tissue covering them, are permeable to liquids; but, to insure the most favourable conditions for the discharge of fluid, it is requisite that the vessels should be divided into their finest or capillary branches, and that they should be arranged in close order, and as near as possible to the surface. In this condition, their coats are reduced to the greatest degree of tenuity and simplicity, and the blood, being divided into minute streams, is more extensively and thoroughly brought into contact with the permeable parietes of its containing channels, as well as more effectually and, by reason of its slower motion, for a longer time exposed to those influences, whether operating from within or without the vessels, which promote transudation.

It seems not unreasonable to conceive that such a simple arrangement as that just indicated would suffice for the separation of certain substances from the general mass of the blood; for the coats of the vessels and tissue superjacent to them are not permeated with equal facility by all its constituents; nay, it is not unlikely that, in certain instances of secretion actually occurring, the elimination of fluid is effected without the necessary aid of any more complicated apparatus. Thus, the exhalation of carbonic acid and watery vapour from the interior of the lungs and air-passages, is probably produced in this simple manner, although the structure of the exhaling membrane is, for other reasons, complex; and the discharge of fluid into cavities lined by serous membranes, which is known to be preternaturally increased by artificial or morbid obstruction in the veins, may be a case of the same kind.

But another element is almost always introduced into the secreting structure, and plays an important part in the secretory process; this is the nucleated cell. A series of these cells, which are usually of a spheroidal or polyhedral figure, is spread over the secreting surface, in form of an epithelium, which rests on a simple membrane, named the basement membrane, or membrana propria. This membrane, itself extravascular, limits and defines the vascular secreting surface; it supports and connects the cells by one of its surfaces, whilst the other is in contact with the blood-vessels, and it may very possibly, also, minister, in a certain degree, to the process of secretion, by allowing some constituents of the blood to pass through it more readily than others. But the cells are the great agents in selecting and preparing the special ingredients of the secretions. They attract and imbibe into their interior those substances which, already existing in the blood, require merely to be segregated from the common store, and concentrated in the secretion, and they, in certain cases, convert the matters which they have selected into new chemical compounds, or lead them to assume organic structure. A cell thus charged with its selected or converted contents yields them up to be poured out with the rest of the secretion, the contained substance escaping from it either by exudation, or, as is probably more common, by dehiscence

of the cell wall, which, of course, involves the destruction of the cell itself. Cells filled with secreted matter may also be detached and discharged entire with the fluid part of the secretion, and, in all cases, new cells speedily take the place of those which have served their office. The fluid effused from the blood-vessels, no doubt supplies matter for the nutrition of the secreting structure, besides affording the materials of the secretion, the residue, when there is any, being absorbed.

Examples, illustrative of the secreting agency of cells, are afforded both by plants and animals.* Thus, cells are found in the liver of various animals, and especially of crustaceans and molluscs, some of which contain a substance resembling coloured biliary matter, and others particles of fat. Also, in the urinary organ of molluscs, cells are seen which inclose little opaque masses of uric acid. The secretion of the sebaceous follicles in man often contains detached cells filled with fat; and, according to Mr. Goodsir's observation, the ink-bag of the cuttle-fish is lined with an epithelium, the constituent cells of which are charged with pigment, similar to that which imparts the dark colour to the inky secretion. This last instance, as well as the production of spermatozoa, is an example of the formation of new products within secreting cells, a process further illustrated in plants, which afford abundant and decided evidence of the production of young cells, spermatic filaments, starch granules, oil, various colouring matters, and other new compounds, in the interior of cells.

Both in animals and plants, the individual cells which are associated together on the same secreting surface, may differ from each other in the nature of their contents. Thus, Dr. H. Meckel states, that in the liver of mollusca he found some cells containing biliary matter, and others containing fat; and in the recent soft parts of the epidermis and its appendages, it is quite common to see cells filled with pigment mixed with others which are colourless.

A secreting apparatus, effectual for the purpose which it is essentially destined to fulfil, may thus be said substantially to consist of a simple membrane, named the membrana propria or basement membrane (marked *a* in the plan, fig. 295), supporting a layer of secreting cells on one of its surfaces (indicated by the dotted line *b*, in the figure), whilst finely ramified blood-vessels are spread over the other (*c*). But, whilst the structure remains essentially the same, the configuration of the secreting surface, or (what amounts to the same thing) of the supporting basement membrane, presents various modifications in different secreting organs. In some cases the secreting surface is plain, or, at least, expanded, as in various parts of the serous, synovial, and mucous membranes, which may be looked on as

Fig. 295.

Plan of a secreting membrane. *a*. Membrana propria, or basement membrane. *b*. Epithelium, composed of secreting nucleated cells. *c*. Layer of capillary blood-vessels.

* See various instances of animal secreting cells adduced by Goodsir, Bowman, H. Meckel, Dr. T. Williams, and others.

examples of comparatively simple forms of secreting apparatus; but, in other instances, and particularly in the special secretory organs named glands, the surface of the secreting membrane is variously involved and complicated. An obvious, and no doubt a principal, purpose of this complication is to increase the extent of the secreting surface in a secreting organ, and thus augment the quantity of secretion yielded by it. No connexion has been clearly shown to exist between the *quality* of the secretion and the particular configuration, either internal or external, of the organ; on the other hand, we know that the same kind of secretion that is derived from a complex organ in one animal, may be produced by an apparatus of most simple form in another.

Keeping now in view that the more immediate purpose of the complication of the secreting membrane is to augment its surface within a comparatively circumscribed space, two principal modes suggest themselves in which the membrane might so increase its extent, namely, by rising or advancing, in form of a prominent fold or some otherwise shaped projection (fig. 296, *d*), or by retiring, in form of a recess (fig. 297, *g*).

The first-mentioned mode of increase, or that by *projection*, is not what is most generally followed in nature, still it is not without example, and, as instances, we may cite the Haversian fringes of the synovial membranes, the urinary organ of the snail, which is formed of membranous lamellæ, and perhaps, also, the choroid plexuses in the brain, and the ciliary processes in the eyeball, although secretion may not be the primary office of the last-mentioned structures. In most of these cases, the membrane assumes the form of projecting folds, which, for the sake of further increase of surface, may be again plaited and complicated, or cleft and fringed, at their borders (fig. 296, *e*, *f*).

Fig. 296.

Plan to show augmentation of surface by formation of processes. *a*, *b*, *c*, as in preceding figure. *d*, simple, and *e*, *f*, branched or subdivided processes.

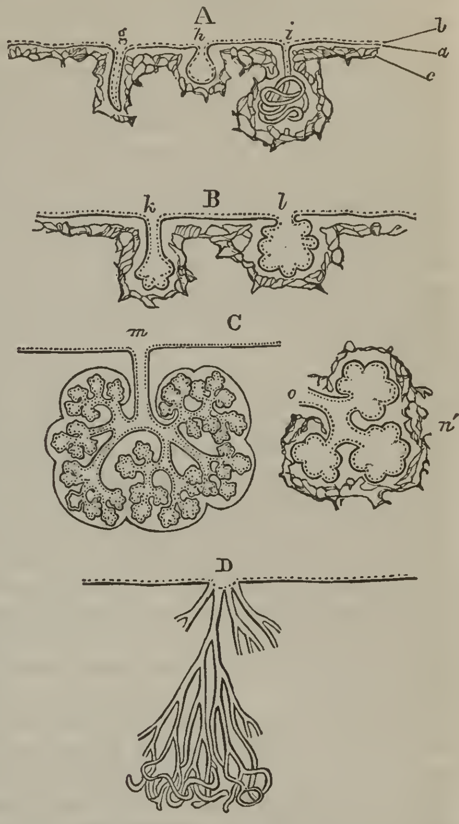
The plan of augmenting the secreting surface by *recession* or *inversion* of the membrane, in form of a cavity, is, with few exceptions, that generally adopted in the construction of secreting glands. The first degree is represented by a simple recess (fig. 297, *g*, *h*), and such a recess, formed of secreting membrane, constitutes a *simple* gland. The shape of the cavity may be tubular (*g*) or saccular (*h*), and, in either case, it is called indifferently a *crypt*, *follicle*, or *lacuna*, for these names have not been strictly distinguished in their application. Examples of these simple glands are found in the mucous membrane of the stomach, intestines, and some other parts. The secreting surface may be increased, in a simple tubular gland, by mere lengthening of the tube, in which case, however, when it acquires considerable length, it is coiled up into a ball (fig. 297, *i*), so as to take up less room, and afford more ready access to its compactly ramified blood-

vessels. The sweat glands, already described, and the ceruminous glands of the ear, are instances of simple glands formed of a long convoluted tube. But the great means adopted for further increasing the secreting surface, is by the subdivision, as well as extension, of the cavity, and when this occurs the gland is said to be *compound.* There is, however, a condition which might be looked on as a step between the simple and compound glands, in which the sides or extremity of a simple tube or sac become pouched or loculated (fig. 297, *k*, *l*). This form might be named the *multilocular crypt.*

In the compound glands, the subdivisions of the secreting cavity may assume a tubular or a saccular form, and this leads to the distinction of these glands into the "tubular," and the "vesicular," "cellular," or "racemose."

The *racemose* or *vesicular* compound glands (fig. 297, *m*), contain a multitude of small rounded vesicles or saccules, opening, in little clusters, into the extremities of a branched tube, named the excretory duct. The little rounded vesicles are, as usual, formed by a proper or basement membrane, and lined, or often rather filled, with secreting cells (fig. 297, *n*); they are arranged in groups, each group opening into a commencing branch of the duct and clustering round it; or it might, with equal truth, be said, that the branches of the duct are distended at their extremities into clusters of vesicular dilatations. The ultimate branches of the duct open into larger branches (*o*), these into larger again, till they eventually terminate in one or more principal excretory ducts (*m*), by which the secretion is poured out of the gland. It is from the clustered arrangement of their ultimate vesicular recesses that these glands are named "racemose," and they, for the most part, have a distinctly lobular structure. The lobules are

Fig. 297.



Plans of extension of secreting membrane, by inversion or recession in form of cavities. A. Simple glands, viz., *g*, straight tube, *h*, sac, *i*, coiled tube. B. Multilocular crypts, *k*, of tubular form, *l*, saccular. C. Racemose or vesicular compound glands. *m*. Entire gland, showing branched duct and lobular structure. *n*. A lobule, detached with *o*, branch of duct proceeding from it. D. Compound tubular gland.

held together by the branches of the duct to which they are appended, and by uniting cellular tissue, which also supports the blood-vessels in their ramifications. The larger lobules are made up of smaller ones, these of still smaller, and so on, for several successions. The smallest lobules (fig. 297, *n*), consist of two or three groups of terminal vesicles, with a like number of ducts, joining into an immediately larger ramuscule (*o*), which issues from the lobule; and a collection of the smallest lobules, united by cellular tissue and vessels, forms one of the next size, which, too, has its larger branch of the duct, formed by the junction of the ramuli belonging to the ultimate lobules. In this way, the whole gland is successively made up, the number of its lobules and of the branches of its duct depending on its size; for whilst some glands of this kind, like the parotid and pancreas, consist of innumerable lobules, connected by a large and many-branched duct, others, such as the duodenal glands of Brunner and many mucous glands, are formed of but two or three ultimate lobules, or even of a single one, with a duct, minute in size, and sparingly branched, to correspond. In fact, a small racemose gland resembles a fragment of a larger one.

A great many compound glands, yielding very different secretions, belong to the racemose or vesicular class. As examples, it will be sufficient to mention the pancreas, the salivary, lachrymal, and mammary glands, with the glands of Brunner already referred to, and most of the small glands which open into the mouth, fauces, and windpipe. From the description given of their structure, it will be understood why the term "conglomerate glands" has been applied especially, though not exclusively, to this class. Their smallest lobules were called *acini*, a term which has also been used to denote the saccular recesses in the lobules, and indeed the word *acinus*, which originally meant the seed of a berry or the stone of a grape, or sometimes the grape itself, has been so vaguely applied by anatomists, that it seems better to discard it altogether.

Of the *tubular* compound glands, the most characteristic examples are the testicle and kidney. In these the tubular ducts divide again and again into branches, which, retaining their tubular form, are greatly lengthened out. The branches of the ducts are, as usual, formed of a limitary or basement membrane, lined by epithelium, and in contact, by its opposite surface, with capillary blood-vessels. By the multiplication and elongation of the tubular branches a vast extent of secreting surface is obtained, whilst, to save room, the tubes are coiled up into a more or less compact mass, which is traversed and held together by blood-vessels, and sometimes, also, divided into lobules and supported, as in the testicle, by fibro-cellular partitions, derived from the inclosing capsule of the gland. In consequence of their intricately involved arrangement, it is difficult to find out how the tubular ducts are disposed at their extremities. It seems probable, however, that some are free, and simply closed without dilatation, and that others anastomose with neighbouring tubes, joining with them in form of loops; in the kidney, little round tufts of fine blood-vessels

project into terminal or lateral dilatations of the ducts, but without opening into them.

The human liver does not precisely agree in structure with either of the above classes of compound glands. Its ducts, which are neither coiled nor dilated, would seem to begin within its lobules in form of a very close network, occupying the interstices of the reticular capillary blood-vessels, which also are peculiar, inasmuch as they receive and transmit venous blood.

Lastly, there are certain anomalous little bodies, connected with the mucous membrane of the intestines, known by the names of the solitary and the agminated glands, which differ from all those hitherto spoken of, inasmuch as they are small saccules without an opening, and seem to discharge their contents, from time to time, by bursting. But the full description of these glands, as well as of the peculiarities in the structure of the liver and kidney above referred to, belongs to the details of special anatomy.

Besides blood-vessels, the glands are furnished with lymphatics, but the arrangement of these within the compound glands, though it is most probably reticular, has not been fully traced. Branches of nerves have also been followed, for some way, into these organs, and the well-known fact, that the flow of secretion in several glands is affected by mental emotions, shows that an influence is exerted on secreting organs through the medium of the nerves. It has not been ascertained how the ultimate ramifications of the nerves are disposed of in the glandular structure, nor how they are related to its more immediate constituents.

From what has been stated, it will be apparent that the substance of a gland consists of the ducts, blood-vessels, lymphatics, and a few nerves, in some cases connected by an intervening tissue. In the testicle there is a very small amount of intermediate cellular tissue, which with the aid of the blood-vessels, holds the tubules but feebly together, so that the structure is comparatively loose, and readily admits of being teased out; but then it is sufficiently protected and supported by the fibrous capsule on the outside, and the septa within the gland. In the racemose or vesicular glands, there is a good deal of uniting cellular tissue, which surrounds collectively each group of vesicles, binds together the lobules, and supports the vessels in their ramifications. The substance of the kidney contains scarcely any distinctly characterized cellular tissue, unless bundles which here and there accompany the larger branches of vessels, but, according to Mr. Bowman, there is more or less of a soft amorphous granular matter among the tubules and blood-vessels, which binds them together, especially in the pyramids, where they have a straight course. *Parenchyma* is a word sometimes employed in describing the glands, though less in use now than formerly. It has sometimes been employed merely to denote the solid part of a gland composed of all the tissues already mentioned; at other times, it has been used to signify any substance, of whatever nature, lying between the ducts, vessels, and nerves. In this last sense, the parenchyma is, in certain glands, re-

presented by cellular tissue, in others, as the kidney, by amorphous matter, whilst there are some in which it cannot be said to exist.

Some glands have a special envelope, as is the case with the kidney and testicle; others, as the pancreas, have none.

The ducts of glands ultimately open into cavities lined by mucous membrane, or upon the surface of the skin. They are sometimes provided with a reservoir, in which the secretion is collected, to be discharged when the purposes of the economy or the convenience of the individual demand. The reservoir of the urine receives the whole of the secreted fluid; in the gall-bladder, on the other hand, only a part of the bile is collected. The vesiculæ seminales afford another example of these appended reservoirs. The ducts are constructed of a basement membrane and lining of epithelium, and in their smaller divisions there is nothing more, but in the larger branches and trunks a fibro-vascular layer is added, as in the ordinary mucous membrane, with which many of them are continuous, and with which they all agree in nature. A more or less firm outer coat, composed of cellular tissue, comes, in many cases, to surround the mucous lining, and between the two, or, at any rate, outside the mucous coat, there are in many ducts muscular fibres of the plain variety, disposed in two layers, in the more internal and more considerable of which layers the fibres run longitudinally, and in the other circularly. The epithelium is usually composed of spheroidal or polyhedral particles at the commencement of the ducts, and is columnar in the rest of their length, though sometimes flattened or scaly, as in the mammary gland.

ORGANS OF RESPIRATION.

THE organs of respiration consist of the thorax (already described), the *lungs* and the windpipe. The *larynx*, which is affixed to the upper end of the air-tube, and opens above into the pharynx, will be separately described afterwards.

THE TRACHEA AND BRONCHI.

The *trachea* or *windpipe*, (τραχεια αρτηρια, arteria aspera,) the common air-passage of both lungs, is an open tube which commences at the larynx above, and divides below into two smaller tubes, named the right and the left bronchus, there being one for each lung.

The trachea is placed in the middle line of the body, being situated partly in the neck and partly in the thorax, and extends from the lower border of the cricoid cartilage of the larynx on a level with the fifth cervical vertebra, to opposite the third dorsal vertebra in the thorax, where it is crossed in front by the arch of the aorta, and at or immediately below that point bifurcates into the two bronchi. It usually measures from four inches to four inches and a half in length, and from three quarters of an inch to one inch in width; but its length and width are liable to continual variation, according to the position of the larynx and the direction of the neck; moreover it usually widens a little at its lower end, and its diameter is always greater in the male than in the female. In form the trachea resembles a cylinder, rounded in front and at the sides, but flattened behind. Its rounded portion is firm and resistant, owing to that part of its walls containing a series of horizontal cartilaginous rings, which, however, are deficient behind, so that the posterior flattened portion is entirely membranous.

The trachea is nearly everywhere invested by a loose cellular tissue, and is very movable on the surrounding parts. Both in the neck and in the thorax, it rests behind against the œsophagus, which intervenes between it and the vertebral column, and towards its lower part projects somewhat to its left side. The recurrent nerves ascend to the larynx between these two tubes.

In the neck, the trachea is situated between the great vessels, its sides being close to the common carotid arteries; at its upper end it is embraced by the lateral lobes of the thyroid body, the middle part or isthmus of which crosses over it just below the larynx. It is also covered in front by the sterno-thyroid and sterno-hyoid muscles, and in the small interval between the muscles of the two sides by the deep cervical fascia. The inferior thyroid veins and the *arteria thyroidea ima* (of Neubauer), when that vessel exists, also lie upon its anterior surface; whilst at the root of the neck, in the episternal notch, the

innominate artery and the left carotid pass obliquely over it as they ascend to gain its sides.

In the thorax, the trachea is covered by the first piece of the sternum, together with the sterno-thyroid and sterno-hyoid muscles; lower down, by the left innominate vein, then by the commencement of the innominate artery and left carotid, which pass round to its sides, next by the arch of the aorta and the deep cardiac plexus of nerves, and quite at its bifurcation, by the place of subdivision of the pulmonary artery. Placed between the two pleuræ, the trachea is contained in the posterior mediastinum, and has on its right side the pleura and pneumogastric nerve, and on the left, the left carotid artery, the pneumogastric and its recurrent branch, together with some cardiac nerves.

The two *bronchi*, (fig. 207, *b*, *b*,) named from their relative position *right* and *left*, commence at the bifurcation of the trachea behind the arch of the aorta, and proceed laterally, one towards the root or place of attachment of each lung, where they are found on a plane posterior to the pulmonary arteries and veins. They differ from each other in length, width, direction, and connexion with other parts. The *right* bronchus, wider but shorter than the left, measuring about an inch in length, passes outwards almost horizontally into the root of the right lung on a level with the fourth dorsal vertebra: it is embraced above by the vena azygos, which hooks forwards over it, to end in the vena cava superior; the right pulmonary artery lies at first below it and then in front of it. The *left* bronchus, smaller in diameter, but longer than the right, being nearly two inches in length, inclines obliquely downwards and outwards beneath the arch of the aorta, to reach the root of the left lung, which it enters on a level with the fifth dorsal vertebra, that is, about an inch lower than the right bronchus. The left bronchus crosses in front of the œsophagus and descending aorta; the arch of the aorta turns backwards and to the left over it, and the left pulmonary artery lies first above it and then on its anterior surface. The remaining connexions of each bronchus, as it lies within the root of the corresponding lung, and the mode in which it subdivides there into bronchia, will be presently described.

In form the bronchi exactly resemble the trachea on a smaller scale; they are rounded and firm in front and at the sides, where they are provided with imperfect cartilaginous rings, and they are flattened and membranous behind.

Structure of the Trachea.

The trachea is composed of a series of thin horizontal cartilages, resembling in form imperfect rings, which are connected together by a continuous membranous tube, consisting chiefly of a fibrous layer lined in its interior by the mucous membrane belonging to the air passages. The walls of the trachea also contain muscular fibres, elastic tissue, and glands, besides vessels, nerves, and cellular tissue.

The *cartilages* and *fibrous membrane.*—The cartilages are from sixteen to twenty in number. Each has the form of a ring or hoop imperfect behind, so as to represent rather more than two-thirds of a

circle, and resembling, when removed from the connecting fibrous membrane, the letter C. Their depth from above downwards is from one line and a half to two lines, and their thickness half a line. The outer surface of each is flat, but the inner surface is rounded or convex from above downwards: this is best seen upon a vertical section, which is thicker in the middle and thinner at the upper and lower edge. They are held together by a strong fibrous membrane which connects the edges of the adjacent cartilages. This membrane is elastic and extensible in a certain degree, and not only occupies the intervals between the cartilages, but is prolonged over their outer and inner surfaces, so that they are, as it were, embedded in it. The layer covering the outer side of the rings is stronger than that within them, and from this circumstance, together with the roundness of their inner surfaces, they may be felt more prominently on the interior than the exterior of the trachea.

The cartilages terminate abruptly behind, (fig. 308, *r*.) At the back of the trachea, where they are altogether wanting, the fibrous membrane (*l*) is continued across between their ends, but it is here looser in its texture.

The first or highest cartilage, which is connected by the fibrous membrane with the lower margin of the cricoid cartilage, is broader than the rest, and is often divided at one end. Sometimes it coalesces in a greater or less extent with the cricoid or with the succeeding cartilage. The lowest cartilage, which is placed at the bifurcation of the trachea into the bronchi, is also peculiar in shape: thus, in the middle it is very deep and thick, owing to its lower border being prolonged downwards, and at the same time bent backwards, so as to form a curved projection between the two bronchi; whilst, on each side, it is produced into a short semicircular or imperfect ring, which embraces the commencement of the corresponding bronchus. The cartilage next above this one is slightly widened in the middle line. Of the other cartilages, it is found, that sometimes the extremities of two adjacent ones are united together, and that not unfrequently a cartilage is divided at the end into two short branches, the opposite end of the next one being likewise bifurcated so as to maintain the parallelism of the entire series. The use of these cartilaginous hoops is to keep the trachea open, a condition essential for the maintenance of the respiratory function.

Muscular fibres.—Between the fibrous and the mucous membrane at the posterior flattened part of the trachea, there is found a continuous pale reddish layer, consisting of transverse muscular fibres (fig. 308, *n*), which pass across, not only between the posterior extremities of the cartilages, but opposite the intervals between the rings also. Those which are placed opposite the cartilages are attached to the ends of the rings, and encroach also for a short distance upon the adjacent part of their inner surface.

These fibres belong to the involuntary class of muscular fibres, and are destitute of striæ. They are best seen by taking away the fibrous membrane and the small glands of the trachea from behind. They can approximate the ends of the cartilages, so as to render the walls of the trachea tense, and at the same time diminish its area.

Elastic fibres.—Situated immediately beneath the tracheal mucous membrane, and adhering intimately to it, are numerous longitudinal fibres of yellow elastic tissue. They are found all round the tube, internal to the cartilages and the muscular layer, but are much more abundant along the posterior membranous part, where they are principally collected into distinct longitudinal bundles, which produce visible elevations or flutings of the mucous membrane. These bundles are particularly strong and numerous opposite the bifurcation of the trachea. The elastic longitudinal fibres serve to restore the windpipe to its ordinary length after it has been stretched in its movements.

The *glands.*—The trachea is provided with very numerous mucous glands, the constant secretion from which serves to lubricate its internal surface. The largest of these glands are small roundish lenticular bodies, situated at the back part of the tube, lying close upon the outer surface of the fibrous layer, or occupying little recesses formed between its meshes (fig. 308): these are compound glands; their excretory ducts pass forwards between the muscular fibres and open on the mucous membrane, where multitudes of minute orifices are perceptible. Other similar but smaller glands are found upon and within the fibrous membrane between the cartilaginous rings. Lastly, there appear to be still smaller glands lying close beneath the mucous coat.

The *mucous membrane.*—This, which is continuous above with that of the larynx, and below with that of the bronchi and their ramifications, is smooth and of a pale pinkish-white colour in health, though when congested or inflamed, it becomes intensely purple or crimson. It is covered with a ciliated columnar epithelium, the vibratile movements of which, as is best seen at the back of the trachea, tend to drive the mucous secretion upwards towards the larynx.

Vessels and nerves.—The arteries of the trachea are principally derived from the inferior thyroid; the veins enter the adjacent plexuses of the thyroid veins. The nerves come from the trunk and recurrent branches of the pneumogastric, and from the sympathetic system.

Structure of the Bronchi.

The general structure of the bronchi corresponds with that of the trachea in every particular. Their *cartilaginous* rings, which resemble those of the trachea in being imperfect behind, are, however, shorter and narrower. The number of rings in the right bronchus varies from six to eight, whilst in the left, the number is from nine to twelve.

The bronchi are supplied by the bronchial arteries and veins, and the nerves are from the same source as those of the trachea.

THE LUNGS AND PLEURÆ.

The *lungs* (pulmones) are double organs situated in the lateral parts of the thorax, one right and the other left, on each side of the heart and large vessels, from which they are separated by the pericardium, and by the two layers of the pleura which form the median partition

or mediastinum already described (vol. i. p. 469). They occupy by far the larger part of the cavity of the chest, and during life are so accurately adapted to its varying dimensions, that they are always in contact with the internal surface of its walls. Each lung is attached at a comparatively small part of its inner or median surface by a part named the *root*, and by a thin membranous fold which is continued downwards from it. In other directions the lung is free, and its surface is closely covered by a serous membrane, proper to itself and to the corresponding side of the thorax, and named accordingly, the right or left *pleura*.

THE PLEURÆ.

The *pleuræ* are two independent serous membranes forming two shut sacs, quite distinct from each other, which line the right and left sides of the thoracic cavity, form by their approximation in the middle line the mediastinal partition, and are reflected each upon the root and over the entire free surface of the corresponding lung.—There is, therefore, a right and a left pleural sac.

Each pleura consists of a *visceral* and a parietal portion, the former being named *pleura pulmonalis*, because it covers the lung; and the latter, where it lines the ribs and intercostal spaces, being called *pleura costalis*. The parietal portion also includes that part which covers the upper convex surface of the diaphragm, and the median layer which enters into the formation of the mediastinum and is reflected on the sides of the pericardium.

Owing to the oblique position of the heart downwards and towards the left, that portion of the mediastinum which extends between the pericardium and the back of the sternum, named the *anterior mediastinum*, has also an oblique direction, so that its lower end is found a little to the left side of that bone. Somewhat higher than the middle of the sternum, and at a little distance behind its second piece, the two layers of the anterior mediastinum, that is, the *two pleuræ* touch each other over a small space, their contiguous surfaces being closely connected together by cellular tissue. Above and below this point, and also immediately behind the bone, there is an interval between the layers, which also inclines downwards and to the left, and contains certain parts already noticed. Proceeding backwards from the anterior mediastinum, the two pleuræ cover the sides of the pericardium as far as the root of the lung, and behind that part pass on to reach the sides of the vertebral column, thus forming the *posterior mediastinum*, which, with its important contents, has been previously described.

At the root of each lung, which is enclosed by its own pleura, the visceral and parietal portions of this membrane are continuous with each other; and commencing immediately at the lower border of the root, there is found a triangular fold or duplicature of the serous membrane, extending vertically between the inner surface of the lung and the posterior mediastinum, and reaching down to the diaphragm, to which it is attached by its point: this fold, which serves to attach the lower part of the lung, is named *ligamentum latum pulmonis*.

The upper part of each pleura, which receives the apex of the corresponding lung, projects in the form of a cul-de-sac through the superior aperture of the thorax into the neck, reaching an inch, or even an inch and a half above the margin of the first rib, and passing up between the lower end of the scaleni muscles,—a small slip of which arising from the transverse process of the last cervical vertebra, is described by Mr. Sibson* as expanding into a dome-like aponeurosis or fascia, which covers or strengthens the pleural cul-de-sac, and is attached to the whole of the inner edge of the first rib. The right pleura is generally stated to reach higher in the neck than the left, but in twenty observations recorded by Mr. Hutchinson,† the right lung was higher in ten cases, and the left in eight, whilst in two the height was equal on the two sides. Owing to the height of the diaphragm on the right side (corresponding with the convexity of the liver), the right pleural sac is shorter than the left; it is at the same time wider.

Structure.—The pleura possesses the usual characters of serous membrane. The costal part of the membrane is the thickest, and may be easily raised from the ribs and intercostal spaces. On the pericardium and diaphragm the pleura is thinner and more firmly adherent, but it is thinnest and least easily detached upon the surface of the lungs.

THE LUNGS.

Form.—Each lung is of a conical shape, having its base turned downwards, and its inner side much flattened. The *base* is broad, concave, and of a semilunar form, and rests upon the arch of the diaphragm. It is bounded all round by a thin margin, which is received in the interval between the ribs and the costal attachment of the diaphragm; and it reaches much lower down behind, and at the outer side than in front and towards the middle line. The *apex* forms a blunted point, and as already mentioned, reaches into the root of the neck, above the margin of the first rib, where it is separated from the first portion of the subclavian artery by the pleural membrane.

The *outer surface* of the lung, which moves upon the thoracic parietes, is smooth, convex, and of great extent, corresponding with the arches of the ribs and costal cartilages. It is of greater depth behind than in front. The *posterior* border is obtuse or rounded, and is received into the deep groove formed by the ribs at the side of the vertebral column; measured from above downwards, it is the deepest part of the lung. The *anterior* border is thin and overlaps the pericardium, forming a sharp margin, which touches the sides of the anterior mediastinum, and, opposite the middle of the sternum, is separated during inspiration from the corresponding margin of the opposite lung only by the two thin and adherent layers of the mediastinal septum. The *inner surface* of the lung, which is flattened or concave, is turned towards the mediastinum, and is adapted to the convex pericardium. Upon this surface, somewhat above the middle of the lung, and considerably nearer to the posterior than the anterior border, is the part called the *root*, where the bronchi and great vessels enter and pass

* Op. citat.

† Op. citat. postea.

out. Each lung is traversed by a long and deep fissure, which is directed from behind and above, downwards and forwards. It commences upon the posterior border of the lung, about three inches from the apex, and extends obliquely downwards to the anterior margin, penetrating nearly through to the root of the organ. The portion of lung, or *upper lobe*, (fig. 207,[9] and [11],) as it is called, which is situated above this fissure, is smaller than the one below it, and is shaped like a cone with an oblique base, whilst the *lower* and larger lobe ([10] and [13]) is more or less quadrilateral. In the right lung only there is a second and shorter fissure, which runs forwards and upwards from the principal fissure to the anterior margin, thus marking off a third small portion, or *middle lobe* ([12]), which appears like an angular piece separated from the anterior and lower part of the upper lobe. The left lung, which has no such middle lobe, presents a deep notch in its anterior border, into which the apex of the heart (enclosed in the pericardium) is received. Besides these differences the right lung is shorter, but at the same time wider than the left, the perpendicular measurement of the former being less, owing to the diaphragm rising higher on the right side to accommodate the liver, whilst the breadth of the left lung is narrowed, owing to the heart and pericardium encroaching on the left half of the thorax. On the whole, however, as is seen on comparisons of weight, the right is the larger of the two lungs.

Weight, dimensions, and capacity.—The lungs vary much in size and weight according to the quantity of blood, mucus, or serous fluid, they may happen to contain, which is greatly influenced by the circumstances immediately preceding death, as well as by other causes. The weight of both lungs together, as generally stated, ranges from thirty to forty-eight ounces, the more prevalent weights being found between thirty-six and forty-two ounces. The proportion borne by the right lung to the left is about twenty-two ounces to twenty, supposing the weight of both to be forty-two ounces. The lungs are not only absolutely heavier in the male than in the female, but appear to be heavier in proportion to the weight of the body. The general ratio between the weight of the lungs and body, in the adult, fluctuates, according to the estimate of Krause, between one to thirty-five and one to fifty.

The following tables, deduced from Dr. Reid's and Mr. Hutchinson's observations, show the average weights of the right and left lungs, and of both lungs together, and also the relative weight of the lungs to the body in a certain number of adults, of both sexes.

AVERAGE OF TWENTY-NINE MALES AND TWENTY-ONE FEMALES.—(REID.)

	MALE.	FEMALE.
Right lung	24 oz.	17 oz.
Left lung	21 oz.	15 oz.
	45 oz.	32 oz.

AVERAGE OF TWENTY-FIVE MALES AND THIRTEEN FEMALES.—(REID AND HUTCHINSON.)

	MALE.	FEMALE.
Proportionate weight of the lungs to the body	1 to 37	1 to 43

The *size* and *cubical* dimensions of the lungs are influenced so much by their

state of inflation, and are therefore so variable, that no useful application can be made of the measurements sometimes given. The quantity of *air* which they contain under different conditions has been investigated by many inquirers, whose statements on this point, however, are exceedingly various. The volume of air contained in the lungs after a forced expiration has been estimated by Goodwyn at 109 cubic inches. After an ordinary expiration it would seem that at least 60 cubic inches more are retained in the chest, giving a total of 169 cubic inches in that condition of the lungs. The amount of air drawn in and expelled in ordinary breathing, has been very differently estimated by different observers; it is most probably from 16 to 20 cubic inches. The recent extensive and important researches of Mr. Hutchinson on this subject, have led him to the conclusion that, on an average, men of mean height, between five and six feet, can, after a complete inspiration, expel from the chest, by a forced expiration, 225 cubic inches of air at a temperature of 60°. This quantity is called by Mr. Hutchinson the *vital capacity* of the lungs. If to it be added the average quantity found by Goodwyn to be retained in the lungs after complete expiration, viz., 109 cubic inches, the result will yield 335 cubic inches of air at 60°, as the average total capacity of the respiratory organs for air in an adult male of ordinary height.

The *vital capacity* (or difference between extreme expiration and extreme inspiration) is found by Hutchinson to bear a singularly uniform relation to the *height* of the individual, increasing eight cubic inches for every additional inch of stature above five feet. Its relations with the *weight* of the body are not thus regularly progressive, for it appears to increase about one cubic inch for each additional pound between the weights of 105 pounds and 155 pounds, or 7½ stone and 11 stone, and to *decrease* at a similar rate between the weights of 11 and 14 stone, or 155 and 200 pounds. From the age of 15 to 35 years the vital capacity continues to advance with the growth and activity of the frame, but between the ages of 35 and 65 it diminishes at the rate of upwards of one cubic inch per annum. This differential or *vital capacity* is by no means in proportion to the *size of the thorax*, whether that be estimated by the circumference of the chest, or by the sectional area of its base, or by its absolute capacity, as ascertained by measuring its cubical contents after death. It is found rather, that the vital capacity is strictly commensurate with the *extent* of the *thoracic movements*, and with the *integrity of the lungs* themselves; so that in phthisis, for example, it becomes reduced by 10 to 70 per cent, according to the stage of the disease. Changing from the erect to the sitting posture is accompanied by a diminution of the vital capacity, which in one case fell from 260 cubic inches to 255 cubic inches, and on lying down it was further diminished to 230 cubic inches in the supine, and 220 cubic inches in the prone position of the body. Lastly, it is lowered by from 12 to 20 cubic inches, by the presence of a full meal in the stomach.*

Texture and consistence.—The substance of the lung is of a light porous spongy structure, and, when healthy, is buoyant in water; but in the fœtus, before respiration has taken place, and also in cases of congestion or consolidation from disease, the entire lungs, or portions of them, will sink in that fluid. The specific gravity of a healthy lung, as found after death, varies from 345 to 746, water being 1000. When the lung is fully distended its specific gravity is 126, whilst that of the pulmonary substance, entirely deprived of air, is 1056. (Krause.) When squeezed, the lungs impart to the finger a crepitant sensation, which is accompanied by a peculiar noise, both effects being owing to the air contained in the tissue. On cutting into the lung, the same crepitation is heard, and there exudes from the cut surface a reddish frothy fluid, which is partly mucus from the air-tubes and air-cells, and partly a serous exudation, tinged with blood and rendered frothy by

* See Mr. Hutchinson's Papers, (Journal of Statistical Society, Aug. 1844, and Medico-Chirg. Transactions, vol. xxix. 1846,) for further details, for a description of the mode of measuring the vital capacity, and of the application of this measurement as a test of the health.

the admixed air. This fluid escapes in largest quantity from the posterior portion of the lung.

The pulmonary tissue is endowed with great elasticity, in consequence of which, the lungs collapse to about one-third of their bulk, when the thorax is opened and the resistance offered by the walls of that cavity to the atmospheric pressure on their outer surface is in this way removed. Owing to this elasticity also, the lungs, when artificially inflated out of the body, resume their previous volume if the air be again allowed to escape.

Colour.—In infancy the lungs are of a pale rose-pink colour, which might be compared to blood-froth; but as life advances they become darker, and are mottled or variegated with spots, patches, and streaks of dark slate-colour, which sometimes increase to such a degree as to render the surface uniformly black. The dark colouring matter to which this is owing is deposited mostly near the surface of the lung; it is not found so abundantly in the deeper substance. It exists sometimes in the air-cells, and on the coats of the larger vessels. Its quantity increases with age, and is said to be less abundant in females than in men. In persons who follow the occupation of colliers, the lungs are often intensely charged with black matter. The black colouring substance of the lung is unlike the black pigment of the choroid coat of the eye or of the negro's skin, for it is not destroyed by the action of chlorine. It seems to be a carbonaceous mixture, consisting of carbon and some animal matter. A black substance of precisely the same nature is found in the bronchial glands.

Opinions differ as to the source of this carbonaceous deposit; some have contended that it is introduced into the lungs from without, by the inhalation of minute particles of carbon floating in the air: the very dark colour of the lungs of colliers has been supposed to favour this view, but it is by no means established. On the contrary, it is supposed by many that its existence is in some way connected with the chemical changes incidental to the respiratory process,—that, for example, it may consist of carbon eliminated from the blood, not as carbonic acid, but in the form of a solid deposit within the pulmonary tissue.

STRUCTURE OF THE LUNGS.

The lungs are composed of an external or serous coat, a subserous cellular layer, and of the pulmonary substance. Beneath the serous covering, which has been already noticed, is a thin layer of *subserous* cellular membrane mixed with much elastic tissue. It is continuous with the cellular tissue in the interior of the lung, and has been described as a distinct coat under the name of the second or inner layer of the pleura. In the lungs of the lion, seal, and leopard, this subserous layer forms a very strong membrane, composed principally of elastic tissue.

The *substance* of the lung is composed of numerous small lobules which are attached to the ramifications of the air-tubes, and are held together by those tubes, by the blood-vessels, and by an interlobular cellular tissue. These lobules are of various sizes, the smallest uniting into larger ones; they are polyhedral, or bounded by flattened sides, and are thus compactly fitted to each other and to the larger air-tubes

and vessels of the lungs. On the surface of the organ they are pyramidal, with a lozenge-shaped base turned outwards, from half a line to a line in diameter: in the interior of the lung they have many sides, and are of various shapes. Though mutually adherent, they are quite distinct one from the other, and may be readily separated by dissection in the lungs of young animals, and in those of the human fœtus.

The *interlobular cellular tissue* which invests these lobules and connects them together, and is continuous with the sub-pleural cellular membrane, is very fine. It is generally moistened with serosity, is traversed by numerous lymphatic vessels, and contains no fat. In one form of disease of the lung, named interlobular emphysema, this intermediate tissue becomes inflated with air, which has escaped by rupture from the interior of the lobules. By forcing air beneath the serous coat of the lung, this condition may be imitated after death; and in either case the lozenge-shaped bases of the larger lobules may be seen on the surface of the organ bounded by elevated lines formed by the inflated interlobular tissue.

These small pulmonary lobules may be regarded as lungs in miniature, the same elements entering into their composition as form the lung itself. The structure of a single lobule represents in fact that of the entire organ, each lobule, besides its investment of cellular membrane, being made up of the following constituents: the *air-tubes* and their *terminating cells*, the *pulmonary* and *bronchial* blood-vessels, with lymphatics, nerves, and interstitial cellular tissue. The different vessels and nerves just enumerated enter the lung by its root. Up to that point the air-tubes, or right and left bronchi, have already been traced, and the bronchial arteries and veins, and the lymphatics have also been elsewhere described. We will now follow the pulmonary vessels up to the same point.

PULMONARY ARTERY AND VEINS.

The *pulmonary artery*, (fig. 207,[5],) is a short wide vessel, which carries the dark blood from the right side of the heart to the lungs. It arises from the infundibulum or conus arteriosus of the right ventricle, and passes for the space of nearly two inches upwards, and at the same time backwards and to the left side, to reach the concavity of the aortic arch, where it bifurcates into its right and left branches, *a*, *a*. The mode of attachment of the pulmonary artery to the base of the ventricle has already been fully noticed. At each side of its commencement is the corresponding coronary artery springing from the aorta, and in contact with its sides are the two auricular appendages. It is at first in front of the aorta, and conceals the origin of that vessel; but higher up, where it lies in front of the left auricle, it crosses to the left side of the ascending aorta, and is finally placed beneath the transverse part of the arch. The pulmonary artery and the aorta are connected together by the serous layer of the pericardium, which for the space of about two inches forms a single tube around both vessels. Rather to the left of its point of bifurcation it is connected to the under side of the aortic arch by means of a short fibrous

cord, which passes obliquely upwards, backwards, and to the left. This is the remains of a large vessel peculiar to the fœtus, named the ductus arteriosus, which has been previously described.

The *two branches* of the *pulmonary artery*.—The *right branch*, longer and somewhat larger than the left, runs almost transversely outwards behind the ascending aorta and the superior vena cava into the root of the right lung. The *left branch*, shorter than the right, passes horizontally in front of the descending aorta and left bronchus into the root of the left lung.

Pulmonary Veins.—The *pulmonary veins*, (fig. 207, *v*, *v*,) which convey the red blood back from the lungs to the left side of the heart, ultimately converge into *four* short venous trunks, which are found two on each side in the root of the corresponding lung. The two veins of the *right* side, which are longer than those of the left, pass below the right pulmonary artery, and behind the superior vena cava, the right auricle, and the aorta, to enter the left auricle. The two *left* pulmonary veins reach the same cavity after a shorter course, passing in front of the descending aorta.

Root of the Lung.

The root of each lung is composed of the bronchus and the large blood-vessels, together with the nerves, lymphatic vessels and glands, all of which parts are closely connected together by cellular tissue, and are enclosed in a sheath formed by the reflection of the pleura.

The root of the right lung lies behind the superior vena cava and part of the right auricle, and below the azygos vein, which arches over it to enter the superior cava. That of the left lung passes below the arch of the aorta, and in front of the descending aorta. The phrenic nerve descends in front of the root of each lung, and the pneumogastric nerve behind, whilst the ligamentum latum pulmonis is continued from the lower border. The bronchus, together with the bronchial arteries and veins, the lymphatics and lymphatic glands, are placed on a plane posterior to the great blood-vessels; the pulmonary artery lies more forward than the bronchus, and to a great extent conceals it, whilst the pulmonary veins are still further in advance. The pulmonary plexuses of nerves lie on the anterior and posterior aspect of the root beneath the pleura, the posterior being the larger of the two.

The order of position of the great air-tube and pulmonary vessels from above downwards differs on the two sides (see fig. 207); for whilst on the right side the bronchus is highest and the pulmonary artery next, on the left, the air-tube, in getting beneath the arch of the aorta, has to pass below the level of the left pulmonary artery, which is the highest vessel. On both sides the pulmonary veins are the lowest of the three.

Before entering the substance of the lung, the bronchus divides into two branches, an upper and a lower, one being intended for each corresponding lobe. The lower branch is the larger of the two, and on the right side gives off a third small branch which enters the

middle lobe of that lung. The subsequent ramifications of the bronchi through the lungs have been distinguished by the name of *bronchia*.*

The pulmonary artery also divides, before penetrating the lung to which it belongs, into two branches, of which the lower is the larger and supplies the lower lobe. The upper of these two branches, gives the branch to the middle lobe. A similar arrangement prevails in regard to the right pulmonary veins, the upper one of which is formed by branches proceeding from the superior and middle lobes of the right lung.

Arrangement and Structure of Parts within the Lung.

The Air-tubes.—The principal subdivisions of the bronchi, go on dividing and subdividing in succession into smaller and smaller tubes, named generally the *bronchia* or the *bronchial* tubes, which diverge through the lung in all directions, and never anastomose. The prevailing form of division is dichotomous; but sometimes three branches arise together, and often lateral branches are given off at intervals from the sides of a main trunk. The larger branches diverge at rather acute angles, but the more remote and smaller ramifications spring more and more obtusely. After a certain stage of subdivision, each bronchial tube is reduced to a very small calibre, and, forming what has been termed *a lobular bronchial tube*, enters a distinct pulmonary *lobule*, within which it undergoes still further division, and at last ends in the small cellular recesses named the *air cells* or *pulmonary cells*. It follows, therefore, that a multitude of air-cells, supported and invested by cellular tissue and opening into the finest branches of a lobular bronchial tube, constitute together with vessels and nerves a *pulmonary lobule*,—that several of these combined together form a larger lobule,—and that a large number of these again are aggregated together to form a *lobe*.

Within the lungs the air-tubes are not flattened behind like the bronchi and trachea without, but form completely circular tubes. Hence, although they contain the same elements as the large air-passages, reduced gradually to a state of tenuity, they possess certain peculiarities of structure. Thus, the *cartilages* no longer appear as imperfect rings running only upon the front and lateral surfaces of the air-tube, but are scattered over all sides of the tube in the form of irregularly-shaped plates of various sizes, adapted as it were to each other. These cartilaginous laminæ are most marked at the points of division of the bronchia, where they form a sharp concave ridge projecting inwards into the tube. They may be traced, becoming however rarer and rarer, and of course greatly reduced in size, as far as those divisions of the bronchia, which are only one-fourth of a line in diameter, beyond which the tubes are entirely membranous. The use of these cartilages is evidently to keep the air-tubes open; and the reason why they are not found in the finest branches is probably because these can never be completely emptied of air. The *fibrous* coat extends to the very smallest tubes, becoming thinner by degrees and degenerating into cellular tissue. The *mucous membrane*, which

* "Eos ramos veteres *bronchia*, *syringes* et *aortas* dixerunt." Haller, Elem. Phys.

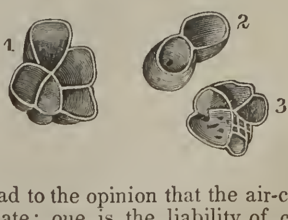
extends throughout the whole system of air-passages, and is continuous with that lining the air-cells, is also thinner than in the trachea and bronchus, but it retains its ciliated columnar epithelium. The yellow longitudinal bundles of *elastic* fibres are very distinct in both the large and small bronchia, and may be followed as far as the tube can be laid open. The *muscular* fibres, which in the trachea and bronchi are confined to the back part of the tube, here surround it with a continuous layer of annular fibres, lying inside the irregular cartilaginous plates; they are found, however, beyond where the cartilages exist, and appear as irregular annular fasciculi even in the smallest tubes: they are pale and unstriped, and have all the characters of the involuntary muscular fibres.

The Air-cells, or *Pulmonary cells.*—These cells, in which the finest ramifications of each lobular bronchial tube ultimately terminate, are in the natural state always filled with air. They are readily seen on the surface and upon a section of a lung which has been inflated with air and dried; also upon portions of fœtal or adult lung injected with mercury. In the lungs of some animals, as of the lion, cat, and dog, they are very large, and are distinctly visible on the surface of the organ. In the adult human lung they vary from $\frac{1}{200}$ to $\frac{1}{70}$th of an inch in diameter; they are larger on the surface than in the interior, and largest towards the thin edges of the organ: they are also said to be very large at the apex of the lung. Their dimensions go on increasing from birth to old age, and they are larger in men than in women. In vesicular emphysema, and in asthmatic persons, they are unnaturally and sometimes enormously increased in size.

Very different opinions as to the mode of communication of the air-cells with each other and their connexion with the bronchial tubes have been entertained. All anatomists are now agreed that the cells of one lobule, isolated by its investing membrane, do not communicate with those of another. Some, however, maintain that the cells within each lobule communicate freely by lateral anastomoses, or even so as to form a labyrinth of short canals, enclosed by the proper membrane of the lobule and opening into its bronchial tube. By others again, it is held that the air-cells do not communicate directly, but are the terminations of the air-tubes, which ramify like a tree without anastomosing, and have been supposed to end either in bunches of blind dilated extremities (Willis), or in very short hemispherical pullulations, which are scarcely if at all dilated (Reisseissen).

[Fig. 298 represents groups of air-cells, of the size of nature, from an emphysematous lung. 1. A group of air-cells laid open and exhibiting the fact that there is no lateral intercommunication. 2. Two air-cells; the one to the left exhibits its bronchiolar orifice. 3. Another group; to the left is represented two cells freely communicating from the partition being ruptured by over-distension; and between the two cells to the right is observed some inflated areolæ of areolar tissue.—J. L.]

[Fig. 298.



[There are two sources of error which may lead to the opinion that the air-cells of the lungs directly and freely intercommunicate: one is the liability of confounding intercellular areolar tissue when inflated with the air-cells themselves;

the other, is the liability of mistaking the bronchioles for air-cells. If all these points be carefully distinguished, and a group of air-cells, in the vicinity of a bronchiole, be examined one after another with a microscope of moderate power, it will be found that each cell has but one opening, and that into the bronchiole, and that there are no lateral intercommunications. This fact may be more satisfactorily determined if a portion of inflated lung which has been in an emphysematous condition be examined, in which air-cells will be frequently observed so largely dilated that their integrity may be seen with the naked eye, as indicated in figure 298, representing several groups of air-cells drawn the size of nature from a preparation by Dr. Goddard.—J. L.]

From recent observations on the lungs of man and mammalia,* it would appear that, on tracing one of the smaller bronchial tubes, suppose for example one entering a separate lobule, the small air-tube divides and subdivides from four to nine times, according to the size of the lobule; its branches, which diverge at more and more obtuse angles, at first diminish at each subdivision, but afterwards continue stationary in size, being about $\frac{1}{50}$th to $\frac{1}{30}$th of an inch in diameter. Moreover, they gradually lose their cylindrical form, and appear more like irregular passages through the substance of the lung, which are beset, at first sparingly, but afterwards closely and on all sides, with numerous little recesses or dilatations, and ultimately terminate near the surface of the lobule in a group of similar recesses. These small recesses or loculi, whether seated along the course or at the extremity of an air-passage, are in fact the *air-cells.* They give the loculated character to a section of the lung, as seen when magnified by a moderate power, which reveals a honeycomb structure, traversed by the comparatively large air-passages. The cells themselves appear like polyhedral alveolar cavities, separated from each other by thin and rather shallow intervening septa, and of course opening into the air-passages. They do not open into one another by anastomosis or lateral communication, but freely communicate through the medium

Fig. 299.

Three diagrams, to show the progressive advance in the cellular structure of the lung of reptiles.—A. The upper portion of the lung of a serpent: the summit has cellular walls, the lower part forms merely a membranous sac. B. Lung of the frog, in which the cellular structure extends over the whole internal surface of the lung, but is more marked at the upper part. C. Lung of the turtle: the cells here have extended so as to occupy nearly the whole thickness of the lung.

of the common air-passage to which they belong. The ultimate arrangement of the finest air-passages and air-cells in the lungs of mammalia would seem, therefore, closely to resemble, though on a

* See Rainey, Med. Chir. Transact, vol. xxviii. 1845. Rossignol, Recherches sur la Structure intime du Poumon, &c., Bruxelles, 1846.

smaller scale, the reticulated structure of the tortoise's lung, in which large open passages lead in all directions to clusters of wide alveoli, separated from each other by intervening septa of various depths.

At the point where the small bronchial tubes lose their cylindrical character, and become covered on all sides with the cells, their structural elements also undergo a change. The *muscular* fibres disappear, the longitudinal elastic bundles are broken up into an interlacement of areolar and *elastic tissue,* which surrounds the tubes and forms the basis of their walls. The *mucous* membrane becomes less opaque, and ceases to be provided with a ciliated epithelium. On the contrary, it is exceedingly delicate, consisting merely of a thin transparent membrane, covered by a stratum of squamous epithelium. A similar membrane lines the air-cells, and by a doubling inwards of itself, forms the intervening septa. The walls of the cells, their orifices, and the margins of the septa, are supported and strengthened by scattered and coiled elastic fibres. The arrangement of the capillary vessels will be noticed immediately.

[Fig. 300.

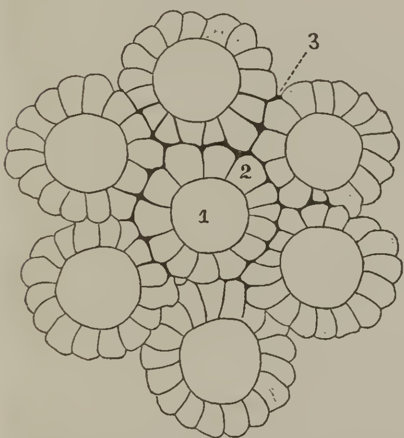
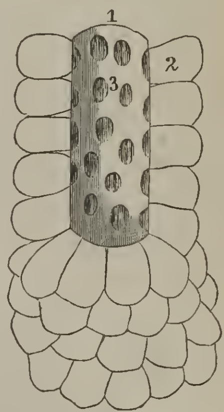


Fig. 301.



The relative arrangement of the air-cells to the bronchioles will be better understood by the student upon examining the annexed diagrams. Fig. 300 represents a transverse section of a portion of parenchyma of the lungs. 1. The orifices of bronchioles. 2. The air-cells arranged around the bronchioles, and opening into them, but not communicating laterally. 3. Interspaces filled with areolar tissue, which, when inflated, is liable to be mistaken for the true air-cells.

Fig. 301 represents a longitudinal section of a terminating bronchiole. 1. The bronchiole, in which are seen the orifices (3) of the air-cells (2) arranged around it and at its termination.—J. L.]

The pulmonary vessels.—These vessels, which are very large, and convey the blood sent through the lung for aeration, have the following arrangement within that organ:—

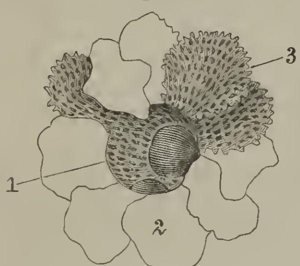
The branches of the *pulmonary* artery accompany the bronchial tubes, but they subdivide more frequently, and are much smaller, especially in their remote ramifications. They do not anastomose in their course, and at length terminate upon the walls of the air-cells in a fine and dense *capillary network,* from which the radicles of the *pulmonary veins* arise. The smaller branches of these veins, especially near the

surface of the lung, frequently do not accompany the bronchia and arterial branches (Dr. T. Addison, Bourgery), but are found to run alone for a short distance through the substance of the organ, and then to join some deeper vein which does run by the side of a bronchial tube, uniting together, and also forming, according to Rossignol, frequent lateral communications. The veins coalesce into large branches, which at length accompany the arteries, and thus proceed to the root of the lung. In their course through the lung, the artery is usually found above and in front of a bronchial tube, and the vein below.

The pulmonary vessels are peculiar, inasmuch as the artery conveys dark blood, whilst the veins carry red blood. The pulmonary veins, unlike the other veins of the body, are not more capacious than their corresponding arteries; indeed, according to Winslow, Santorini, Haller, and others, they are somewhat less so. These veins have no valves. Lastly, it may be remarked, that whilst the arteries of different lobules are independent, their veins freely anastomose together.

The *capillary* network of the pulmonary vessels is spread beneath the thin transparent mucous membrane of both the terminal and lateral air-cells, and is found wherever the finest air-tubes have lost their cylindrical character, and become beset with cells. Around the bottom of each cell there is an arterial circle, which communicates freely with similar neighbouring circles, the capillary system of ten or twelve cells being thus connected together, as may be seen upon the surface of the lung. From these circular vessels, which vary in diameter from $\frac{1}{1270}$ to $\frac{1}{846}$ inch, the capillary network arises, covering the bottom of each cell, ascending also between the duplicature of mucous membrane in the intercellular septa, and surrounding the openings of the cells. According to Mr. Rainey, the capillary network, where it rises into the intercellular partitions, forms a double layer in the lungs of reptiles, but is single in the lungs of man and mammalia.

[Fig. 302.



Represents the relative arrangement of air-cells to a bronchiole, and the disposition of the capillaries. 1. A bronchiole; at its bottom is seen the orifices of two smaller bronchioles, and upon its surface a capillary rete communicating with that (3) of the air-cells (2). From a preparation by Topping. —J. L.]

The capillaries themselves are very fine, the smallest measuring, in injected specimens, from $\frac{1}{2540}$ to $\frac{1}{5000}$th inch; the network is so close that the meshes are scarcely wider than the vessels themselves. The coats of the capillaries are also exceedingly thin, and thus more readily allow of the free exhalation and absorption of which the pulmonary cells are the seat. Keil and Hales estimated the entire extent of the inner surface of the air-tubes and pulmonary cells at more than 21,000 square inches; but no great reliance can be placed on such calculations.

The bronchial vessels.—The bronchial *arteries* and *veins*, which are much smaller than the pulmonary vessels, carry blood for the nutrition

of the lung, and are doubtless, also, the principal source of the mucous secretion found in the interior of the air-tubes, and of the thin albuminous fluid which moistens the pleura pulmonalis.

The *bronchial arteries*, from one to three in number for each lung, arise from the aorta, or from an intercostal artery, and follow the divisions of the air-tubes through the lung. They are ultimately distributed in three ways: many of their branches ramify in the bronchial lymphatic glands, the coats of the large blood-vessels, and on the walls of the large and small air-tubes, as far as these retain their cylindrical form and their opaque ciliated mucous membrane; others form plexuses in the interlobular cellular tissue; and lastly, branches spread out upon the surface of the lung beneath the pleura.

The *superficial* set, or subpleural *arteries*, form plexuses and a capillary network, which may be distinguished from those of the pulmonary vessels of the superficial air-cells by their tortuous course and open arrangement, and also by their being outside the investing membrane of the lobules, and by ultimately ending in the branches of the *superficial* set of *bronchial veins.* Of the deeper seated *arteries*, those which supply the bronchial lymphatic glands, and those which penetrate a certain distance upon the air-tubes and large vessels, end in corresponding *deep bronchial* veins; the interlobular arterial plexuses send venous radicles, which end either in the superficial or the deep set of bronchial veins, and serve to connect them together; lastly, the capillary network of the innermost branches of the bronchial arteries, which is found upon the finest cylindrical air-tubes, communicates with the system of pulmonary vessels, so that its blood returns by the pulmonary veins. The exact nature of this last-named communication is difficult to determine, inasmuch as experiments by injection, especially of so delicate a capillary system as that of the lung, are liable either to be defective or to be rendered inaccurate by rupture and extravasation. According to Ruysch, Haller, Sœmmerring, and Reisseissen, the terminations of the deep bronchial arteries anastomose with those of the pulmonary arteries, or, at any rate, the capillary networks of the two sets of vessels anastomose. Rossignol denies even the latter mode of communication, because he could not succeed in injecting from the pulmonary artery the vessels of the cylindrical air-tubes, which are destitute of air-cells: he believes that the only communication between the bronchial and pulmonary vessels is by means of some minute bronchial venous radicles which end in the pulmonary veins.

It was found by Rossignol, first, that injections by the bronchial arteries returned by both the pulmonary and bronchial veins, but not by the pulmonary artery; secondly, that injections by the pulmonary arteries returned entirely by the pulmonary veins, but not by the bronchial arteries; and thirdly, that by injecting the pulmonary veins, it was easy to fill all the other vessels, viz., the pulmonary artery and the bronchial arteries and veins.

The *bronchial veins*, therefore, have not quite so large a distribution in the lung as the bronchial arteries. The superficial and deep veins unite at the root of the lung, and on the right side open into the vena azygos, on the left usually into the superior intercostal vein.

The absorbent vessels.—The lungs are well supplied with lymphatic vessels and glands. The lymphatics consist of a *superficial* and a *deep* set. The former constitute a network on the surface of the lung, and being joined by the interlobular lymphatics of the deep set, which traverse the interlobular cellular tissue, run towards the root of the lung. Here, together with the deep absorbents, they pass through the bronchial lymphatic glands found in that situation. These glands, which are numerous and of considerable size, lie, some within the lung around the largest bronchia, and some near the bifurcation of the trachea and around the bronchi. They have a great tendency to induration, and usually contain much of the peculiar carbonaceous colouring matter already mentioned as existing in the lung, and which is also found in abundance along the course of the lymphatic vessels.

Nerves.—The lungs are supplied by nerves from the anterior and posterior pulmonary plexuses. These are formed chiefly by branches from the pneumogastric nerves, joined by others from the sympathetic system. The fine nervous cords enter at the root of the lung, and follow the air-tubes. Their final distribution requires further examination. According to Remak, whitish filaments (from the par vagum) follow the bronchia as far nearly as the surface of the lung. Grayish filaments proceeding from the sympathetic, and having very minute ganglia upon them in their course, have also been traced by the last-mentioned anatomist to the bronchia and pleura.

DEVELOPMENT OF THE LUNGS AND TRACHEA.

The lungs first appear as two little protrusions upon the front of the œsophageal portion of the alimentary canal, completely hid by the rudimentary heart and liver. These primitive protrusions or tubercles are visible in the chick on the third day of incubation (see fig. 303 for their appearance on the fourth day.) According to Baër and others, they are, from the first, *hollow*, their internal cavities communicating with the œsophagus and being lined by a prolongation of its inner layer. At a later period they are connected with the œsophagus by means of a long pedicle, which ultimately forms the trachea, whilst the bronchia and air-cells are developed by the successive ramification of the internal cavity to form cæcal tubes, after the manner of the ducts of glands. Reichert and Bischoff, on the other hand, are of opinion that the rudiments of the lungs are at first *solid*, and are produced by a thickening or protrusion of the outer layers only of the œsophageal tube. The inner layer never enters them, but they soon become connected with the commencing trachea, which appears like a white streak along the whole length of the œsophagus. The rudimentary lungs, which are at first smooth and undivided, consist of two masses of blastema composed of nucleated cells. In their substance, the bronchi soon begin to form as solid white tracts, which join the trachea, and the future cavity in their interior first appears as a deeper coloured line. The ultimate bronchial ramifica-

Fig. 303.

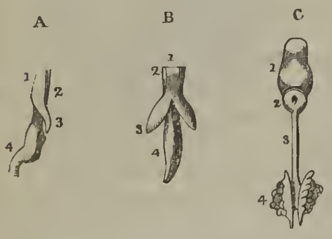


Fig. 303 illustrates the development of the respiratory organs.—(Rathke.)—A. Œsophagus of a chick on the fourth day of incubation, with the rudimentary lung of the left side, seen laterally. 1. The front, and 2. The back of the œsophagus. 3. Rudimentary lung protruding from that tube. 4. Stomach. B. The same seen in front, so as to show both lungs. C. Tongue and respiratory organs of embryo of the horse. 1. Tongue. 2. Larynx. 3. Trachea. 4. Lungs seen from behind.

tions, and probably the air-cells too, are formed by the successive budding out and subsequent excavation of the earlier developed bronchial tubes.

As to the *trachea* itself, its precise mode of origin and formation is undetermined. Baër regards it as a tubular prolongation from the œsophagus, but this is doubtful, and others believe it to be formed upon the œsophagus, and afterwards to open into that canal. According to Fleischmann, the rings of the trachea are seen at the fourth week in the human embryo, formed of lateral halves which afterwards unite. Rathké and Valentin state, on the contrary, that they arise by simple strips of cartilage. They appear to increase in number during development. The vibratile cilia have been seen very early.

For a long time the lungs are very small, and occupy only a little space at the back part of the chest. In an embryo 16 lines in length, their proportionate weight to the body was found by Meckel to be 1 to 25; in another, 29 lines long, it was 1 to 27; at 4 inches in length 1 to 41, and at the full period 1 to 70. Huschke found that the lungs of still-born *male* children were heavier in proportion to the weight of the body than those of female children; the ratio being, amongst females, 1 to 76, and in males 1 to 55.

Changes after birth.—No organ undergoes such rapid and remarkable changes after birth, as those which, in consequence of the commencement of respiration, affect the lungs in almost every respect, viz., in size, position, form, consistence, texture, colour, and weight. An accurate knowledge of these changes furnishes the only means of distinguishing between a still-born child and one that has respired.*

Position, size, and form.—In a fœtus at the full period or in a still-born child, the lungs, comparatively small, lie packed at the back of the thorax, and do not entirely cover the sides of the pericardium; subsequently to respiration, they expand and completely cover the pleural portions of that sac, and are also in contact with every part of the thoracic parietes, which is covered with the pleural membrane. At the same time, their previously thin sharp margins become more obtuse, and their whole form is less compressed.

Consistence, texture, and colour.—The introduction of air, and of an increased quantity of blood into the compact, heavy, granular, yellowish-pink, gland-like substance of the fœtal lungs, which ensues immediately upon birth, converts their tissue into a loose, light, rose pink, spongy structure, which, as already mentioned, floats in water. The changes thus simultaneously produced in their consistence, colour, and texture, occur first at their anterior borders, and proceed backwards through the lungs: they, moreover, appear in the right lung a little in advance of the left.

Weight.—The *absolute weight* of the lungs, having gradually increased from the earliest period of development to birth, undergoes at that time from the blood then poured into them, a very marked addition, amounting to more than one-third of their previous weight: for example, the lungs before birth weigh about one and a half ounce, but, after complete expansion by respiration, they weigh as much as two and a half ounces. The *relative weight* of the lungs to the body, which, at the termination of intra-uterine life is about 1 to 70, becomes, after respiration, on an average about 1 to 35 or 40, a proportion which is not materially altered through life. Their *specific gravity* is at the same time changed from 1·056 to about ·342.

Changes in the trachea after birth.—In the fœtus, the trachea is flattened before and behind, its anterior surface being even somewhat depressed; the end of the cartilages touch; and the sides of the tube, which now contains only mucus, are applied to one another. The effect of respiration is at first to render the trachea open, but still flattened in front; afterwards it becomes convex.

THE LARYNX, OR ORGAN OF VOICE.

The upper part of the air-passage is modified in its structure to form the *organ of voice.* This organ, named the *larynx*, [λαρυνω, to cry,] is

* It must be remembered that these changes may present themselves, in different cases, in every possible degree of variety, owing to the amount of respiration which has taken place, in either or both lungs. For particular details on these points, and also for an explanation of certain sources of fallacy, see the proper treatises on medical jurisprudence.

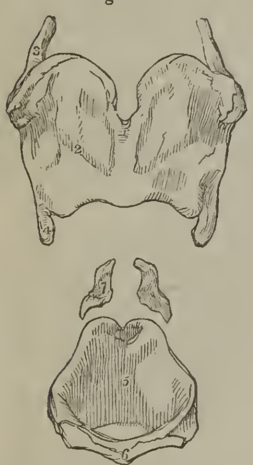
placed at the upper and fore part of the neck, where it forms a considerable prominence in the middle line. It lies between the large vessels of the neck, and below the tongue and os hyoides, to which bone it is suspended. It is covered in front by the cervical fascia along the middle line, and on each side by the sterno-hyoid, sterno-thyroid, and thyro-hyoid muscles, by the upper end of the thyroid body, and by a small part of the inferior constrictor of the pharynx. Behind, it is covered by the pharyngeal mucous membrane, and forms the anterior boundary of the lower part of the pharynx, into which cavity it opens above, whilst below it leads into the windpipe.

The larynx is cylindrical at the lower part, where it joins the trachea, but it widens above, becomes flattened behind and at the sides, and presents a blunted vertical ridge in front.

The larynx consists of a framework of cartilages, articulated together and connected by proper ligaments, two of which, named the *true vocal* cords, are immediately concerned in the production of the voice. It also possesses muscles, which move the cartilages one upon another, a mucous membrane lining its internal surface, numerous mucous glands, and lastly, blood-vessels, lymphatics, and nerves, besides cellular tissue and fat.

Cartilages of the Larynx.

Fig. 304.



Cartilages of the larynx separated and seen in front. 1 to 4. Thyroid cartilage. 1. Vertical ridge, or pomum Adami. 2. Right ala. 3. Superior, and 4, inferior cornu of the right side. 5, 6. Cricoid cartilage. 7. Right arytenoid cartilage.

The cartilages of the larynx consist of three single and symmetrical pieces, named respectively the *thyroid cartilage*, the *cricoid cartilage*, and the *cartilage of the epiglottis*, and of six others, which occur in pairs, namely, the two *arytenoid cartilages*, the *cornicula laryngis*, and the *cuneiform cartilages*. In all, there are nine distinct pieces, the two cornicula and two cuneiform cartilages being very small. Of these, only the thyroid and cricoid cartilages are seen on the front and sides of the larynx (see fig. 304); the arytenoid cartilages, surmounted by the cornicula laryngis, together with the back of the cricoid cartilage, on which they rest, form the posterior wall of the larynx, whilst the epiglottis is situated in front, and the cuneiform cartilages on each side of the upper opening.

The *thyroid* cartilage (cartilago thyreoidea, v. scutiformis; θυρεός, a shield, and ειδος,) is the largest of the pieces composing the larynx. It is formed by two flat lamellæ, united in front, at an acute angle along the middle line, where they form a vertical projection (fig. 304,[1]), which becomes gradually effaced, as it is traced from above downwards. The two lamellæ, diverging one from the other backwards, embrace the cricoid cartilage, and terminate posteriorly by two thick projecting vertical borders, separated widely from each

other; hence, the thyroid cartilage is altogether wanting behind. The angular projection on the anterior surface in the median line is subcutaneous, and is much more prominent in the male than in the female, being named in the former the *pomum Adami.* The *lateral halves* (2), or lamellæ, named the *alæ*, are somewhat quadrilateral in form, and are perfectly symmetrical. The *external* flattened surface of each ala is marked by an indistinct *oblique line*, which, commencing at a tubercle situated at the back part of the upper border of the cartilage, passes downwards and forwards, so as to mark off the anterior three-fourths of the surface from the remaining posterior portion. This line gives attachment below to the sterno-thyroid, and above to the thyro-hyoid muscle, whilst the small smooth surface behind it gives origin to part of the inferior constrictor of the pharynx, and affords attachment, by means of cellular tissue, to the thyroid body. On their *internal* or *posterior* surfaces, the two alæ are smooth, and slightly concave, and by their union in front, form a retreating angle within corresponding with the ridge on the anterior aspect of the cartilage. The greater portion of the internal surface of the thyroid cartilage is connected to other parts, but the upper and posterior portion of each ala is lined loosely by the mucous membrane of the pharynx only, and forms the outer boundary of a lateral groove seen on each side at the back of the larynx. The upper border of the thyroid cartilage is slightly concave at the sides, and deeply notched in the middle line, above the *pomum Adami* (1). This border is connected, in its whole extent, to the os-hyoides by a strong membrane, named the thyro-hyoid. The lower border, which is shorter than the upper, is scolloped out into three shallow concavities, a wider one in the middle and a smaller one at each side, separated from the first by an intervening tubercle. This border is connected with the cricoid cartilage, in the median line by the crico-thyroid membrane, and on each side by the crico-thyroid muscle. The *posterior* borders of the thyroid cartilage, which are rather thick and rounded, have a vertical direction, and are prolonged upwards and downwards, into two processes, named cornua, which form respectively the posterior limits of the shallow lateral notches seen on the upper and lower margins of the cartilage. The stylo-pharyngeus and palato-pharyngeus muscles of each side are attached to these posterior borders. Of the four *cornua,* all of which bend inwards, the two *superior*, or *great* cornua (3), pass backwards, upwards, and inwards, and terminate each by a blunt extremity, which is connected, by means of the lateral thyro-hyoid ligament, to the tip of the corresponding great cornu of the os hyoides. The *inferior*, or *smaller*, cornua (4), which are somewhat thicker but shorter, are directed forwards and inwards, and present each, on the inner aspect of the tip, a smooth surface, for articulation with a prominence on the side of the cricoid cartilage.

The *cricoid cartilage*, so named from its being shaped like a ring (κρικος, a ring; ειδος,) is thicker in substance and stronger than the thyroid cartilage; it forms the inferior, and a considerable portion of the back part of the larynx, and is the only one of the cartilages which completely surrounds this organ. It is deeper behind (5), where the

thyroid cartilage is deficient, measuring in the male about an inch from above downwards, but is much narrower in front ([6]), where its vertical measurement is only two lines and a half. The cricoid cartilage is circular *below*, but *higher* up it is somewhat compressed laterally, so that the passage through it is elliptical, its antero-posterior diameter being longer than the transverse. The *external* surface is convex and smooth in front and at the sides, where it affords attachment to the crico-thyroid muscles, and behind these to the inferior constrictor muscle on each side. The surface posteriorly is three or four times deeper and somewhat broader. It presents in the middle line a slight vertical ridge, to which some of the longitudinal fibres of the œsophagus are attached. On each side of this ridge is a broad depression for the posterior crico-arytenoid muscle, and externally and anteriorly to that a small rounded and slightly raised surface for articulation on either side with the inferior cornu of the thyroid cartilage. The *internal* surface of the cricoid cartilage is smooth, and is lined by the laryngeal mucous membrane. The lower border is rounded and horizontal, and is connected by a membrane to the first ring of the trachea. The upper border which, owing to the greater depth of the cartilage behind, is inclined obliquely upwards and backwards, is connected, in front, to the thyroid cartilage by the crico-thyroid membrane. On each side it gives attachment to the lateral part of the crico-thyroid membrane, and to the lateral crico-arytenoid muscle. Posteriorly this border of the cartilage presents a slight notch in the middle line, which gives origin to some of the fibres of the arytenoid muscle. On the sides of this notch, and consequently on the highest part of the cartilage, are two convex oval articular facets, directed upwards and outwards, to which the arytenoid cartilages are articulated.

The *arytenoid cartilages*, (cartilagines arytænoideæ, v. pyramidales, fig. 304,[7]; αρύταινα, a kind of ewer, ειδος,) are two in number, and are perfectly symmetrical in form. They may be compared to two three-sided pyramids recurved at the summit, measuring from five to six lines in height, resting by their bases on the posterior and highest part of the cricoid cartilage, and approaching near to one another towards the median line. Each measures upwards of three lines in width, and more than a line from before backwards. Of its three faces, the *posterior* is broad, triangular, and excavated from above downwards, so that the summit of the cartilage is curved backwards. This concave smooth surface lodges part of the arytenoid muscle. The *anterior* surface, convex in its general outline, and somewhat rough, gives attachment to the thyro-arytenoid muscle, and, by a small tubercle, to the corresponding superior or false vocal cord. The *internal* surface, which is the narrowest of the three, and somewhat flattened, is parallel with and very near to that of the opposite cartilage, being covered by the laryngeal mucous membrane. The anterior and posterior borders, which limit the internal face, ascend nearly in the same vertical plane, whilst the external border, which separates the anterior from the posterior surface, is directed obliquely upwards and inwards.

The *base* of each arytenoid cartilage is slightly hollowed, having towards its inner part a smooth surface for articulation with the cri-

coid cartilage. Two of its angles are remarkably prominent, viz., one *external*, short, and rounded, which projects backwards and outwards, and into which the posterior and the lateral crico-arytenoid muscles are inserted; the other *anterior*, which is more pointed, and forms a horizontal projection forwards, to which the corresponding true vocal cord is attached.

The *apex* of each arytenoid cartilage curves backwards and a little inwards, and terminates in a rounded point, which is surmounted by a small cartilaginous appendage named corniculum laryngis, to be next described.

The *cornicula laryngis*, or *cartilages of Santorini*, (capitula Santorini,) are two small yellowish cartilaginous nodules of a somewhat triangular or conical shape, which are articulated with the summits of the arytenoid cartilages, and serve as it were to prolong them backwards and inwards. They are sometimes united to the arytenoid cartilages.

The *cuneiform cartilages*, or *cartilages of Wrisberg*, are two very small soft yellowish cartilaginous bodies, placed one on each side of the larynx in the fold of mucous membrane which extends from the summit of the arytenoid cartilage to the epiglottis. They have a conical form, their base or broader part being directed upwards. They occasion small conical elevations of the mucous membrane within the larynx, a little in advance of the cartilages of Santorini, with which, however, they are not directly connected.

The *epiglottis*, (επιγλωττις; fig. 308, *e*,) is a single median part formed by a thin lamella of yellow cartilage, shaped somewhat like a cordate leaf, and covered by mucous membrane. It is placed in front of the superior opening of the larynx projecting upwards immediately behind the base of the tongue. In the ordinary condition its direction is vertical, the free extremity curving forward towards the tongue, but during the act of swallowing it is carried downwards and backwards over the entrance into the larynx, which it covers and protects.

The cartilage of the epiglottis is broad and somewhat rounded at its upper free margin, but inferiorly becomes pointed, and is prolonged by means of a long, narrow, fibrous band (the thyro-epiglottic ligament) to the deep angular depression between the alæ of the thyroid cartilage, to which it is attached, behind and below the median notch. Its *lateral* borders, which are convex, are only partly free, being in part concealed within the folds of mucous membrane which pass back on each side to the arytenoid cartilages. The *anterior* or *lingual* surface is free only in the upper part of its extent, where it is covered by mucous membrane. Lower down, the membrane is reflected from it forwards to the base of the tongue, forming one median fold and two lateral folds or frænula, sometimes called the glosso-epiglottidean ligaments. The adherent portion of this surface is also connected with the posterior surface of the os hyoides by means of a median elastic tissue named the hyo-epiglottic ligament, and is moreover in contact with some glands and fatty tissue. The posterior or *laryngeal* surface of the epiglottis, which is free in the whole of its extent, is convex from above downwards, but concave from side to side. It is

closely covered by the mucous membrane, on removing which, the yellow cartilaginous lamella of which the epiglottis consists is seen to be pierced by numerous little pits and perforations, in which are lodged small glands which open on the surface of the mucous membrane.

Structure of the cartilages of the larynx.—The epiglottis, together with the cornicula laryngis and cuneiform cartilages, are composed of what is called yellow or spongy cartilage, which has little tendency to ossify. The structure of all the other cartilages of the larynx resembles that of the costal cartilages, like which, they are very prone to ossification as life advances.

Ligaments of the larynx.—The ligaments of the larynx are *extrinsic*, or those which connect it with contiguous parts, as the os hyoides and the trachea, and *intrinsic*, by means of which its several cartilaginous pieces are connected one to the other.

Extrinsic ligaments.—The larynx is connected with the os hyoides by a broad membrane and by two round lateral ligaments. The *thyro-hyoid membrane*, or *middle thyro-hyoid ligament*, is a broad, fibrous, and somewhat elastic membrane, which passes up from the whole length of the superior border of the thyroid cartilage to the os hyoides, being attached not to the inferior part of that bone, but along the highest part of its internal or posterior surface. Owing to this arrangement, the top of the larynx, when drawn upwards, is permitted to slip within the circumference of the hyoid bone, between which and the upper part of the thyroid cartilage, there is occasionally found a small synovial bursa. The thyro-hyoid membrane is thick and subcutaneous towards the middle line, but on each side becomes thin and loose, and is covered by the thyro-hyoid muscles. Behind it is the epiglottis with the mucous membrane of the base of the tongue, separated however by much adipose tissue and some glands. It is perforated by the superior laryngeal artery and nerve of each side.

At the posterior limits of the thyro-hyoid membrane are found the right and left *lateral thyro-hyoid ligaments*, rounded yellowish cords, which pass up from the superior cornua of the thyroid cartilage, to the rounded extremities of the great cornua of the hyoid bone. These lateral thyro-hyoid ligaments are distinctly elastic, and frequently enclose a small oblong cartilaginous nodule, which has been named *cartilago triticea:* sometimes this nodule is bony.

The membrane which connects the lower border of the larynx (cricoid cartilage) to the first ring of the trachea, forms the commencement of that tube.

Intrinsic ligaments.—The thyroid and cricoid cartilages are connected together in front and at each side. In the former direction, a strong triangular yellowish ligament, consisting chiefly of elastic tissue, is attached to the contiguous borders of these two cartilages. It is named the *crico-thyroid membrane*, and sometimes the *pyramidal* or *conoid* ligament (fig. 306). Its base is turned downwards, and is fixed to the upper margin of the cricoid cartilage. Its anterior surface is convex and is covered at the sides by the crico-thyroid muscles, and crossed horizontally by a small anastomotic arterial arch, formed by the junction of the crico-thyroid branches of the right and

left superior thyroid arteries. The posterior surface of this membrane is covered only by the mucous membrane of the larynx.

On tracing the crico-thyroid membrane backwards, its lateral portions, which are fixed on each side to the inner lip of the upper border of the cricoid cartilage, become much thinner and are found to be continuous upwards with the lower margin of the inferior or true vocal cords, becoming blended with them firmly in front. These lateral portions of the crico-thyroid membrane, described by Cruveilhier as the *lateral crico-thyroid ligaments*, are lined by the mucous membrane of the larynx, and correspond externally with the lateral crico-arytenoid and adjoining thyro-arytenoid muscles.

On the *sides*, the inferior cornua of the thyroid cartilage are connected by two small but distinct articulations, having each a ligamentous capsule and a synovial membrane, with the sides of the cricoid cartilage. The prominent oval articular surfaces of the cricoid cartilage are directed upwards and outwards, whilst those of the thyroid cartilage, which are slightly concave, look in the opposite direction. The capsular fibres form a stout band behind this small joint, which possesses but little motion.

The *crico-arytenoid* articulations are looser than the crico-thyroid just described. They are surrounded by a series of thin capsular fibres, which, together with a loose synovial membrane, serve to connect the convex elliptical articular surfaces on the upper border of the cricoid cartilage with the concave articular depressions seen on the bases of the arytenoid cartilages. There is, moreover, a strong *posterior crico-arytenoid* ligament on each side, (fig. 309, [13], [18],) arising from the cricoid, and inserted into the inner and back part of the base of the arytenoid cartilage.

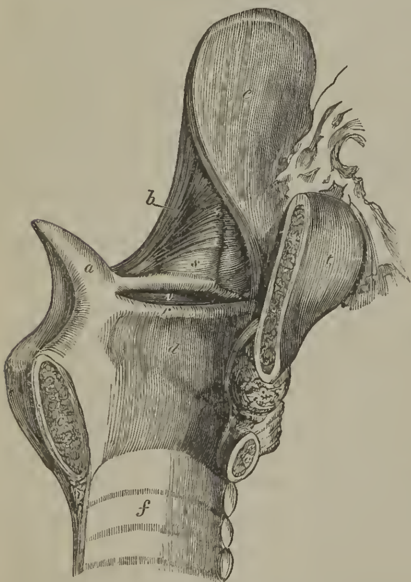
The summits of the arytenoid cartilages and the cornicula laryngis have usually a fibrous and synovial capsule to connect them, but it is frequently indistinct.

Two yellow elastic bands belonging to the epiglottis, named the *hyo-epiglottic* and *thyro-epiglottic* ligaments, which connect the epiglottis in the middle line with the hyoid bone and the thyroid cartilage, have already been incidentally noticed. The *aryteno-epiglottidean* ligaments and the *superior thyro-arytenoid* ligaments or false vocal cords, both of which are little more than folds of mucous membrane, and also the *interior thyro-arytenoid* ligaments or true vocal cords, will be most conveniently described with the interior of the larynx.

Interior of the larynx.—The *superior aperture* of the larynx (see fig. 308), by which it communicates with the pharynx, is a triangular opening, wide in front and narrow behind, the lateral margins of which slope obliquely downwards and backwards. It is bounded in front by the epiglottis (*e*), behind by the summits of the arytenoid cartilages (*a*) and cornicula laryngis with the crescentic border of mucous membrane crossing the median space between them, and on the sides by two folds of mucous membrane, named the *aryteno-epiglottidean folds*, which, enclosing a few ligamentous and muscular fibres, pass forwards from the tips of the arytenoid cartilages and cornicula to the lateral margins of the epiglottis.

On looking down through the superior opening of the larynx, the air-passage below this part is seen to become gradually contracted, especially in its transverse diameter, so as to assume the form of a long narrow fissure running from before backwards. This narrow part of the larynx is called the *glottis*. It is situated on a level with the lower part of the arytenoid cartilages. Below it, at the upper border of the cricoid cartilage, the interior of the larynx assumes an elliptical form, and lower down still it becomes circular. The glottis is bounded laterally by four strongly marked folds of the mucous membrane, stretched from before backwards, two on each side, and named the *vocal cords*. The *superior* vocal cords are much thinner and weaker than the inferior, and are arched or semilunar in form; the *inferior* or *true* vocal cords are thick, strong, and straight. Between the right and left inferior vocal cord is the narrow opening of the glottis, named the *rima glottidis*, and sometimes the *glottis vera*, or *true glottis* (fig. 309,[1]). Bounded above by the superior and below by the inferior vocal cord of each side, are two deep oval depressions, seen, of course, one on each side of the glottis, and named the *sinuses*, or *ventricles* of the larynx (fig. 305, *v*); and lastly, leading upwards from the anterior part of these depressions, and on the outer side of the superior vocal cord, are two small culs-de-sac, named the *laryngeal pouches* (*s*). Each of these parts, which are covered with the mucous membrane, requires a separate description.

Fig. 305.



View of the interior of the left half of the larynx, to show the ventricle and laryngeal pouch. (After Hilton; Guy's Hosp. Reports, No. 5.) *a*. Left arytenoid cartilage. *c, c*. Sections of the cricoid cartilage. *t*. Thyroid cartilage. *e*. Epiglottis. *v*. Left ventricle of the larynx. *r*. Left inferior or true vocal cord. *s*. Laryngeal pouch. *b*. Aryteno-epiglottidean muscle, or compressor sacculi laryngis. *f*. Inside of trachea, which has been added to this figure.

The *superior vocal cords*, also called the *false* vocal cords, because they are not concerned in the production of the voice, are two folds of mucous membrane, containing a few slight fibrous fasciculi, named the *superior thyro-arytenoid* ligaments. These ligaments (above *v*, fig. 305) are fixed in front to the depression between the alæ of the thyroid cartilage, somewhat above its middle close to the attachment of the epiglottis; whilst behind they are connected to the tubercles on the rough anterior surface of the arytenoid cartilages (*a*). Above, they are continuous with the scattered fibrous bundles contained in the aryteno-epiglottidean folds. Below, enclosed in the mucous membrane, each forms

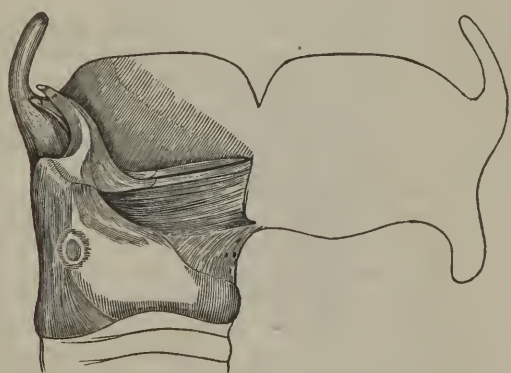
a free crescentic margin, which bounds the corresponding ventricle of the larynx, the aperture of which is seen on looking down into the laryngeal cavity, because the superior vocal cords are separated farther from each other than the inferior cords.

The *inferior* or *true vocal cords* (fig. 305, *r*; 309, ^{3}, ^{3}), for it is by their vibration that the voice is produced, are two bands of elastic tissue, named the *inferior thyro-arytenoid ligaments*, which are attached in front to about the middle of the depression between the alæ of the thyroid cartilage below the superior cords, and are inserted behind to the elongated anterior processes of the base of the arytenoid cartilages. These bands consist of closely arranged parallel fibres. They are continuous below with the thin lateral portions of the crico-thyroid membrane; on their outer side they are in contact with and connected to the fibres of the thyro-arytenoid muscles; in other directions they are free, and are covered by the mucous membrane, which is here so thin and closely adherent as to show the white colour of these ligaments through it. Their upper and free edges, which are sharp and straight, form the lower boundaries of the ventricles, and are the parts thrown into vibration during the production of the voice. Their inner surfaces are flattened, and look towards each other.

[Several years since I published a description* of the arrangement of the ligamentous structure of the larynx, in which the existence of the vocal cords is denied, to which opinion I still adhere.

"If the muscular layer," which is placed beneath the alæ of the thyroid cartilage, "be raised up, the crico-thyroid membrane (fig. 306,) will be exposed.

Fig. 306.



Represents the right ala of the thyroid cartilage thrown forward, the muscles removed, and the membrana vocalis exposed.

This will be found to have its origin from the inner circumference of the superior edge of the cricoid cartilage anterior to the arytenoid cartilages, and from the anterior part of the bases of the latter, and to have its insertion into the interior half of the entering angle of the thyroid cartilage. Its internal face is in contact with the lining or mucous membrane of the larynx, and a good view of it may be obtained by removing the latter. Its anterior inferior part is thickened and

* Am. Journ. of Med. Sci., vol. xii. No. 23, N. S. p. 141. Philada. 1846.

pierced by several foramina for the transmission of blood-vessels; its superior edge is also a little thickened, and is on a line with the inferior edge of the opening of the ventricle of the larynx, constituting what is generally described as a distinct structure, under the name of the inferior thyro-arytenoid ligaments or vocal cords, but which, as such, really do not exist. More properly this membrane cannot be considered to stop here, as it may be traced, though in a very thinned condition, over the whole periphery of the ventricle of the larynx, even so far as the epiglottis."

A little thickening in this membrane at the line corresponding to the superior edge of the orifice of the ventricle of the larynx produces the so-called superior thyro-arytenoid ligaments.

This membrane, which may be called the vocal membrane (membrana vocalis), throughout its whole extent is composed of the yellow elastic tissue, but above the inferior edge of the ventricle of the larynx is intermingled with a good proportion of areolar tissue.—J. L.]

The *rima glottidis* (fig. 309,[1]), an elongated fissure formed between the inferior or true vocal cords, and, posteriorly, between the bases of the arytenoid cartilages, is, when slightly open, of a lancet-shape, the pointed extremity being turned forwards; when further opened it is triangular, becoming widened behind; and in its fully dilated condition it has the figure of an elongated lozenge, with its posterior angle truncated. This aperture is the narrowest part of the interior of the larynx; in the adult male it is about eleven lines, or nearly an inch in its antero-posterior measurement, and about four lines across at its widest part, which may be dilated to nearly half an inch. In the female its dimensions are less, its antero-posterior diameter being about eight lines, and its transverse diameter about two. The vocal ligaments, which are shorter than the glottis, measure about seven lines in the male and five in the female.

The *ventricles*, or *sinuses* of the larynx (fig. 305, *v*), [ventriculi Galeni s. Morgagni,] formed between the superior and inferior vocal cords on each side, are two oblong cavities, narrower at their orifice than in their interior. The upper margin of each is crescentic, and the lower straight; the outer surface is covered by the upper fibres of the corresponding thyro-arytenoid muscle.

The small culs-de-sac, named the *laryngeal pouches* (*s*), lead from the anterior part of the ventricle upwards, for the space of half an inch, between the superior vocal cords on the inner side, and the thyroid cartilage on the outer side, reaching as high as to the upper border of that cartilage at the sides of the epiglottis. Each of these supplementary cavities is conical in shape, and curved slightly backwards, so as to have been compared in form to a Phrygian cap. Its opening into the corresponding ventricle is narrow, and is generally limited by two folds of the lining mucous membrane. Numerous small glands, sixty or seventy in number, open into its interior, and it is surrounded by a quantity of fat. Externally to the fat, this little pouch receives a fibrous investment, which is continuous below with the superior vocal cord. Over its laryngeal side and upper end, is a thin layer of muscular fibres (compressor sacculi laryngis, arytæno-epiglottideus inferior; Hilton) connected above with those found in the aryteno-epiglottidean folds (*b*). The upper fibres of the thyro-arytenoid muscles pass over the outer side of the pouch, some few

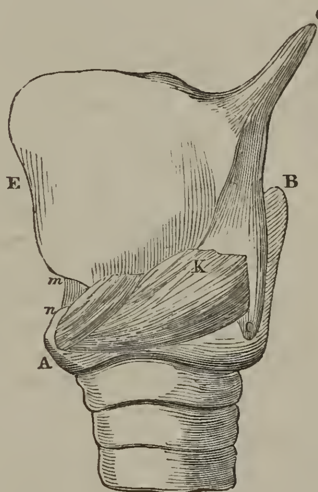
being attached to its lower part. Lastly, the laryngeal pouch is supplied abundantly with nerves, derived from the superior laryngeal.

Muscles of the Larynx.

Besides certain extrinsic muscles already described, viz.: the sterno-hyoid, omo-hyoid, sterno-thyroid, and thyro-hyoid muscles, together with the muscles of the supra-hyoid region, and the middle and inferior constrictors of the pharynx, all of which act more or less upon the entire larynx, there are certain *intrinsic muscles* which move the different cartilages upon one another. These intrinsic muscles are the *crico-thyroid*, the *posterior crico-arytenoid*, the *lateral crico-arytenoid*, the *thyro-arytenoid*, and the *arytenoid*, together with certain slender muscular fasciculi connected with the epiglottis. All these muscles, except the arytenoid, which crosses the middle line, exist in pairs.

The *crico-thyroid muscle* (crico-thyroideus, fig. 307, K), is a short thick triangular muscle, seen on the front of the larynx, situated on

[Fig. 307.

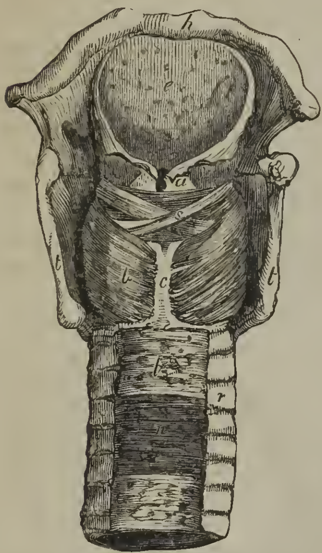


Side view of the thyroid (E, G) and cricoid (A, B) cartilages, with part of the trachea. *m*, *n*, crico-thyroid membrane or ligament. K, crico-thyroid muscle.—C.]

the fore part and side of the cricoid cartilage. It *arises* by a broad origin from the cricoid cartilage, reaching from the median line backwards upon the lateral surface, and its fibres, passing obliquely upwards and outwards and diverging slightly, are *inserted* into the lower border of the thyroid cartilage, from the tubercle on each side of the median notch to the lesser cornu, and also into the anterior border of the latter process. The fibres of insertion reach from half

a line to a line upon the inner surface of the thyroid cartilage. The lower portion of the muscle, which is nearly horizontal in direction, and is inserted into the lesser cornu, is usually distinct from the rest. Some of the superficial fibres are almost always continuous with the inferior constrictor of the pharynx.

Fig. 308.



Posterior view of larynx, and part of trachea, dissected to show the muscles. *a.* Right arytenoid cartilage. *t, t.* Posterior margins of thyroid cartilage. *c.* Back of cricoid cartilage. *h.* Os hyoides. *e.* Epiglottis. *b.* Left posterior crico-arytenoid muscle. *s.* Arytenoid muscle. *l.* Fibrous membrane at back of trachea, with the glands lying in it. *n.* Muscular fibres of the trachea. *r.* Cartilaginous rings of trachea.

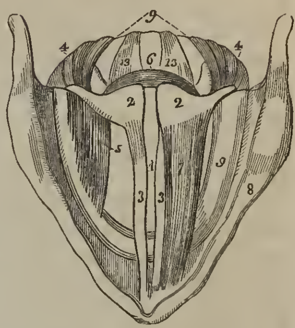
The inner borders of the muscles of the two sides are separated from each other in the middle line by a triangular interval, broader above than below, and occupied by the crico-thyroid membrane. The crico-thyroid muscle is covered by the sterno-thyroid, and it covers the fore part of the lateral crico-arytenoid and thyro-arytenoid muscles: its lower border is in contact with or covered by the thyroid body, and its upper border adjoins the inferior constrictor of the pharynx.

The *posterior crico-arytenoid muscle* (crico-arytænoideus posticus, fig. 308, *b*), is found at the back of the larynx beneath the mucous membrane in that situation. It arises from the broad depression seen on the corresponding half of the posterior surface of the cricoid cartilage. From this broad origin its fibres converge upwards and outwards towards the base of the arytenoid cartilage. The upper fibres are short and almost horizontal; the middle are the longest and run obliquely; whilst the lower or anterior fibres are nearly vertical. The muscle is *inserted* (fig. 309,[4]) by a narrow slip, partly fleshy and partly tendinous, into the external process, or posterior and outer surface of the base of the arytenoid cartilage, behind the attachment of the lateral crico-arytenoid muscle. This muscle is situated between the pharyngeal mucous membrane and the cricoid cartilage.

The *lateral crico-arytenoid muscle* (crico-arytænoideus lateralis, figs. 309;[5] 310,[6]).—To obtain a proper view of this muscle and the thyro-arytenoid, which will be next described, it is necessary to remove the corresponding ala of the thyroid cartilage, by which they are in a great measure hidden. The *lateral crico-arytenoid* is smaller than the posterior, and is of an oblong form. It *arises* from the upper border of the side of the cricoid cartilage, its origin extending as far back as the articular surface for the arytenoid cartilage. Its fibres passing obliquely backwards and upwards, the anterior or upper ones being the longest, are *attached* to the external process or outer side of the base of the arytenoid cartilage and to the adjacent part of its an-

terior surface, in front of the insertion of the posterior crico-arytenoid muscle.

Fig. 309.



A diagram, slightly altered from Willis, showing a bird's-eye view of the interior of larynx. 1. Opening of the glottis. 2, 2. Arytenoid cartilages. 3, 3. Vocal cords. 4, 4. Posterior crico-arytenoid muscles. 5. Right lateral crico-arytenoid muscle; that of the left side is removed. 6. Arytenoid muscle. 7. Thyro-arytenoid muscle of the left side; that of the right side is removed. 8. Upper border of the thyroid cartilage. 9, 9. Upper border and back of the cricoid cartilage. 13. Posterior crico-arytenoid ligament.

This muscle lies in the interval between the ala of the thyroid cartilage and the interior of the larynx, being lined within by the mucous membrane of the larynx. Its anterior part is covered by the upper part of the crico-thyroid muscle. The upper border is in close contact, and indeed, is sometimes blended with the thyro-arytenoid muscle.

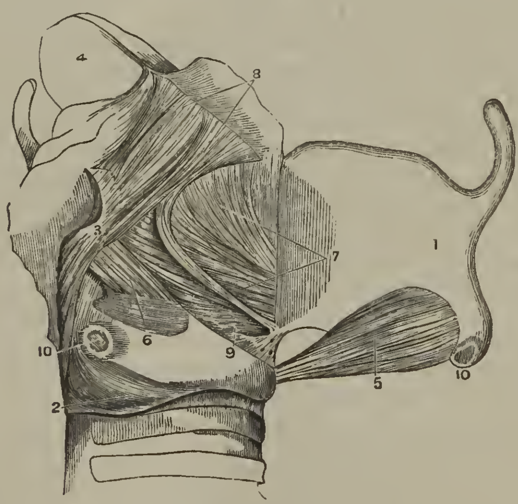
The *thyro-arytenoid* (thyro-arytænoideus, figs. 309;[7] 310,[7]) is a broad flat muscle situated above the lateral crico-arytenoid. It is thick below and in front, and becomes thinner upwards and behind. It consists of several muscular fasciculi, which *arise* in front from the internal surface of the thyroid cartilage, from the lower two-thirds of the retreating angle formed by the junction of the two alæ. They extend almost horizontally backwards and outwards to reach the base of the arytenoid cartilage. The *lower portion* of the muscle, which forms a thick fasciculus, receives a few additional fibres from the posterior surface of the crico-thyroid membrane, and is inserted into the anterior projection on the base of the arytenoid cartilage and to the adjacent part of the surface close to the insertion of the lateral crico-arytenoid muscle. The *thinner portion* of the thyro-arytenoid muscle is *inserted* higher up on the anterior surface and outer border of that cartilage. The lower portion of the muscle lies parallel with the rima glottidis, immediately on the outer side of the corresponding true chorda vocalis with which it is intimately connected, and into the outer surface of which some of its fibres are inserted. According to some authorities, however, the cord and muscle can be completely separated. The upper thin portion lies upon the outer side of the corresponding laryngeal pouch and ventricle close beneath the mucous membrane. The entire muscle may be dissected indeed from the interior of the larynx by raising the mucous membrane and vocal cord. Its outer surface is covered by a loose cellular tissue, which separates it from the internal surface of the ala of the thyroid cartilage. Some of the fibres of this muscle pass round the border of the arytenoid cartilage, and become continuous with some of the oblique fibres of the arytenoid muscle, to be presently described.

Santorini described three thyro-arytenoid muscles, an *inferior* and *middle*, which are constant, and a *superior*, as sometimes present. The fibres of the superior fasciculus, when present, arise nearer to the notch of the thyroid cartilage, and are attached to the upper part of the arytenoid cartilage. This is named by

Sœmmerring the *small* thyro-arytenoid, whilst the two other portions of the muscle constitute the *great* thyro-arytenoid of that author.

Muscular fibres connected with the epiglottis.—Under the name of *thyro-epiglottideus* and *arytæno-epiglottideus* muscle, some thin scattered fasciculi have been noticed and described by anatomists, as extending on each side from the thyroid and arytenoid cartilages to the corresponding margin of the epiglottis. The *thyro-epiglottidean* fibres arise from the inner surface of the thyroid cartilage close upon the outer side of the origin of the thyro-arytenoid muscle, and ascend to reach the margin of the epiglottis. They constitute the *depressor epiglottidis.* The *arytæno-epiglottidean* fibres (fig. 305, *b*) arise from the corresponding arytenoid cartilage just above the point of attachment of the superior vocal cord, and passing forwards spread out so as to cover the upper end and part of the side of the laryngeal pouch on its laryngeal aspect, and are finally inserted by a broad expanse into the margin of the epiglottis. That part of the muscle which covers the pouch was described by Mr. Hilton as the *arytæno-epiglottideus inferior* or *compressor sacculi laryngis*, and is stated by him to be distinguished by a cellular interval from another fasciculus of fibres situated higher up in the aryteno-epiglottidean folds, which might be named the *arytæno-epiglottideus superior.* Sometimes a few of the fibres of the aryteno-epiglottidean muscle appear to be continuous round the outer border of the arytenoid cartilage with some of the oblique fasciculi of the arytenoid muscle.

[Fig. 310.



Represents the larynx with the right ala (1) detached from its connexions and thrown forwards, exhibiting the muscular layer beneath. 2. The cricoid cartilage. 3. The right arytenoid cartilage. 4 Epiglottis. 5. Crico-thyroideus muscle. 6. Crico-arytænoideus lateralis. 7. Thyro-arytænoideus, with the thyro-epiglottidean layer of muscular fibres passing from its upper part. 8 Aryteno-epiglottidean layer of muscular fibres. 9 Inferior anterior part of the crico-thyroid or vocal membrane. 10. Acetabulum for the articulation of the inferior cornu of the thyroid with the cricoid cartilage.—J. L.]

[The muscular fibres connected with the epiglottis are presented in various conditions of development in different larynges. The thyro-epiglottidean layer of fibres, (fig. 310,) appears to be constituted by the divergence of the fibres of the upper edge of the thyro-arytenoid muscle ([7]) having the origin at the entering angle of the thyroid cartilage, and the expanded edge terminating in the areolar tissue, between the fold of mucous membrane extending from the tip of the arytenoid to the epiglottis cartilage and in the margin of the latter. Frequently these fibres are indistinct and occasionally do not exist at all. The aryteno-epiglottidean fibres ([8]) usually form a thin layer, lying external to the expanded portion of the thyro-epiglottidean layer, and attached to the outer side of the arytenoid cartilage at one extremity, and to the margin of the epiglottis at the other. Frequently this layer is separated into two bands by an interspace of areolar tissue. The upper band (arytæno-epiglottideus superior) is usually the smaller; the lower (arytæno-epiglottideus inferior s. compressor sacculi laryngis) is sometimes reinforced by accessory fibres from the thyro-arytænoideus, or by a distinct band curving backwards from the entering angle of the thyroid cartilage. Occasionally the aryteno-epiglottidean layer is indistinct, or, consists only of a few scattered fibres.—J. L.]

The *arytenoid muscle* (arytænoideus, fig. 308, *s*), the only single muscle belonging to the larynx, is situated beneath the mucous membrane on the back of this organ, lying upon the posterior concave surfaces of the arytenoid cartilages, and stretching across the interval between them. This muscle, which is short and thick, arises from the whole length of the outer border and posterior surface of one arytenoid cartilage, and is inserted in the corresponding parts of the other cartilage. It consists of three sets of fibres: one transverse, and two oblique. The transverse fibres (arytænoideus transversus), the deepest and most numerous, pass straight across, whilst the two sets of oblique fibres (arytænoideus obliquus) pass from the base of one cartilage to the apex of the opposite one, crossing each other in the middle line superficially to the transverse set. Some of these oblique fibres become continuous round the side of the arytenoid cartilage with fibres of the thyro-arytenoid and aryteno-epiglottic muscles, as already mentioned.

The lower border of the arytenoid muscle touches the cricoid cartilage, from which a few muscular fibres generally arise; its posterior surface is covered by the pharyngeal mucous membrane, which is prolonged over its upper border and a small part of its anterior surface between the arytenoid cartilages, to be continued into the interior of the larynx.

ACTION OF THE INTRINSIC MUSCLES OF THE LARYNX.

The two *crico-thyroid* muscles (fig. 307,[10]) must cause the thyroid and cricoid cartilages to turn on each other at their posterior articulation, whereby they are made to approach in front, whilst the summit of the cricoid behind is carried forwards upon the cricoid, or, *vice versâ*, the cricoid backwards from the thyroid; and since the arytenoid cartilages are moved backwards together with the cricoid, in consequence of their connexion to it by the strong posterior crico-arytenoid ligaments, the action of the crico-thyroid muscles will be to elongate and tighten the vocal cords. The *posterior crico-arytenoid* muscles (fig. 309,[4],[4]) cause the arytenoid cartilages to swing upon their base with a rotatory movement outwards and backwards, which is not hindered by the aforesaid ligament, so that their anterior processes, together with the attached vocal cords, part from each other, and the opening of the glottis is thus dilated. The *lateral crico-arytenoid* muscles ([5]) swing the arytenoid cartilages back again in the opposite direction to

the last-named muscles, so as to approximate their anterior extremities, and thus contract the opening of the glottis.

The *thyro-arytenoid* muscles (7) also bring the anterior processes of the arytenoid cartilages together, and thus constrict the glottis. According to Mr. Willis, their further and chief action, is to draw forwards the arytenoid cartilages, with the back part of the cricoid cartilage, to which these are affixed, and thus to cause the cricoid cartilage to turn on the inferior cornua of the thyroid, by which means the crico-thyroid interval in front is increased, and the vocal cords are shortened and relaxed; but, according to another opinion, it has been conceived that these muscles tighten the cords by the rotation inwards of the arytenoid cartilages, or by the action of some fibres supposed to be attached to the outer surface of the cords.

The *single arytenoid* muscle (6) approximates the arytenoid cartilages, and thus constricts the posterior part of the rima glottidis. The tendency of some of its fibres, but especially the superficial and oblique ones, to rotate the arytenoid cartilages outwards, and thus, by drawing more apart their anterior processes, to widen the opening of the glottis, is counteracted by the lateral crico-arytenoid muscles. The few scattered fibres of the arytenoid muscle, which, together with those of the *thyro-arytenoid* and *aryteno-epiglottidean* muscles, encircle as it were the upper part of the larynx, must tend to contract its superior aperture. The fasciculi of the thyro-arytænoidei on the outer side, and those of the arytæno-epiglottidei (fig. 305, *b*) upon the summit and inner sides, of the laryngeal pouches, will serve to compress these sacs.

Lastly, the *thyro-epiglottidei*, so far as they operate, are depressors of the epiglottis.

The mucous membrane and glands of the larynx.—The *mucous membrane* of the larynx is continuous above with that of the mouth and pharynx, and below with that of the trachea. Reaching the anterior surface and sides of the epiglottis, from the root of the tongue, it forms the three glosso-epiglottidean folds, and is then reflected over the posterior or laryngeal surface of the epiglottis. From the margins of the epiglottis to the summits of the arytenoid cartilages, it forms the aryteno-epiglottidean folds, or lateral boundaries of the superior aperture of the larynx. Lastly, in the notch between the summits of the arytenoid cartilages, it turns over the upper border of the arytenoid muscle. Sinking thus into the larynx (see fig. 305), it turns over the superior vocal cords, lines the ventricles and sacculi laryngis, and is then reflected over the inferior vocal cords (*r*), below which it descends (*d*) upon the lateral and middle portions of the crico-thyroid membrane, and finally lines the entire inner surface of the cricoid cartilage (*c c*).

The laryngeal mucous membrane is thin and of a pale pink colour. In some situations it adheres intimately to the subjacent parts, especially on the epiglottis, and still more in passing over the true vocal cords, on which it is extremely thin and most closely adherent. About the upper part of the larynx, above the glottis, it is extremely sensitive. In or near the aryteno-epiglottidean folds it covers a quantity of loose cellular tissue, which is liable in disease to infiltration, constituting œdema of the glottis. Like the mucous membrane in the rest of the air passages, that of the larynx is covered in the greater part of its extent with a columnar ciliated epithelium, by the vibratory action of which the mucus is urged upwards. The cilia are found higher up in front than on each side and behind, reaching in the former direction as high as the widest portion of the epi-

glottis, and in other directions, to a line or two above the border of the superior vocal cords: higher than these points the epithelium loses its cilia, and gradually assumes a squamous form, like that of the pharynx and mouth.

Glands.—The lining membrane of the larynx is provided with numerous *glands*, which secrete an abundant mucus; and the orifices of which may be seen almost everywhere, excepting upon and near the true vocal cords. They abound particularly upon the epiglottis (fig. 308, *e*) in the substance of which are found upwards of fifty little compound glands. Between the anterior surface of the epiglottis, the os hyoides, and the root of the tongue, is a mass of yellowish fat, erroneously named the epiglottidean gland, in or upon which some real glands may exist. Another collection of glands, named *arytenoid*, is placed within the fold of mucous membrane in front of each arytenoid cartilage, from which a series may be traced forwards, along the corresponding superior vocal cord. The glands of the laryngeal pouches have already been described.

Vessels and Nerves of the Larynx.

The *arteries* of the larynx are derived from the superior thyroid, a branch of the external carotid, and from the inferior thyroid, a branch of the subclavian. The *veins* join the superior, middle, and inferior thyroid veins. The *lymphatics* are numerous and pass through the cervical glands. The *nerves* are supplied from the superior laryngeal and inferior or recurrent laryngeal branches of the pneumogastric nerve, joined by branches of the sympathetic. The superior laryngeal nerves supply the mucous membrane, and also the crico-thyroid muscles, and in part the arytenoid muscle. The inferior laryngeal nerves supply, in part, the arytenoid muscle, and all the other muscles, excepting the crico-thyroid.

The superior and inferior laryngeal nerves of each side communicate with each other in two places, viz., at the back of the larynx, beneath the pharyngeal mucous membrane, and on the side of the larynx, under the ala of the thyroid cartilage.

DEVELOPMENT AND GROWTH OF THE LARYNX.

Development.—The rudimentary larynx consists, according to Valentin, of two slight enlargements having a fissure between them, and embracing the entrance from the œsophagus into the trachea. According to Reichert, the rudiments of the arytenoid cartilages are the first to appear. Rathké, however, states that all the cartilages form at the same time, and are recognisable together as the larynx enlarges, the epiglottis appearing last. In the human embryo, Fleischmann could not detect the cartilages at the seventh week, though the larynx was half a line in length, but at the eighth week there were visible the thyroid and cricoid cartilages, consisting then and afterwards of two lateral halves, which are united together by the sixth month.

Growth.—During childhood the growth of the larynx is very slow. Richerand found that there was scarcely any difference between the dimensions of this organ in a child of three and in one of twelve years of age. Up to the age of puberty the larynx is similar in the male and female, the chief characteristics at that period being the small size and comparative slightness of the organ, and the smooth rounded form of the thyroid cartilage in front. In the female these conditions are permanent, expecting that a slight increase in size takes place. In the

male, on the contrary, remarkable changes rapidly occur, and the larynx speedily becomes more prominent and more perceptible at the upper part of the neck. Its cartilages become larger, thicker, and stronger, and the alæ of the thyroid cartilage project forward in front so as to form at their union with one another, at an acute angle, the prominent ridge named *pomum Adami*. At the same time the median notch on its upper border is considerably deepened. In consequence of these changes in the thyroid cartilage, the distance between its angle in front and the arytenoid cartilages behind becomes greater, and the chordæ vocales are necessarily lengthened. Hence the dimensions of the glottis, which, at the time of puberty, are increased by about one-third only in the female, are nearly doubled in the male, and the adult male larynx becomes altogether one-third larger than that of the female.

Towards the middle of life, the cartilages of the larynx first show a tendency to ossification; this commences first in the thyroid cartilage, then appears in the cricoid, and lastly in the arytenoid cartilages. In the thyroid cartilage the ossification usually begins at the cornua and posterior borders; it then gradually extends along the whole inferior border, and subsequently spreads upwards through the cartilage. The cricoid cartilage first becomes ossified at its upper border upon each side, near the two posterior auricular eminences, and the ossification invades the lateral parts of the cartilage before encroaching on it either in front or behind. The arytenoid cartilages become ossified from below upwards.

THE THYROID BODY.

The *thyroid body* is a soft, reddish, and highly vascular organ, situated in the lower part of the neck, embracing the front and sides of the upper part of the trachea, and reaching up to the sides of the larynx. From its general resemblance to the glandular organs, it has been called the thyroid *gland*, but it possesses no system of excretory ducts. Its function is unknown, but, owing to its local connexion with the principal cartilage of the larynx, is usually described with that organ, and has received the name *thyroid*. It is of an irregular, semilunar form, consisting of two *lateral lobes*, united together towards their lower ends by a transverse portion named the isthmus. Viewed as a whole, the thyroid body is convex on the sides and in front, forming a rounded projection upon the trachea and larynx. It is covered by the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles, and behind them it comes into contact with the sheath of the great vessels of the neck. Its deep surface is concave where it rests against the trachea and larynx. It usually extends so far back as to touch the lower portion of the pharynx, and on the left side the œsophagus also.

Each *lateral lobe* measures usually two inches or upwards in length, and three-quarters of an inch in its thickest part, which is below its middle. The right lobe is usually a few lines longer and thicker than the left. The general direction of each is, from below, obliquely upwards and backwards, reaching from opposite the sixth ring of the trachea to the posterior border of the thyroid cartilage, of which it covers the inferior cornu and adjoining part of the ala. The upper end of the lobe, which is thinner, and sometimes called the *cornu*, is usually connected to the side of the thyroid and cricoid cartilages by cellular tissue.

The *transverse* part, or *isthmus*, which connects the two lateral lobes together a little above their lower ends, measures nearly half an inch in breadth, and from a quarter to three quarters of an inch in

depth; it commonly lies across the third and fourth rings of the trachea, but is very inconstant in size and shape, so that the portion of trachea left uncovered by it is subject to corresponding variation. From the upper part of the isthmus, or from the adjacent portion of either lobe, but most frequently the left, a conical portion of the thyroid body, named, from its shape and position, the *pyramid* or *middle lobe* (cornu medium, columna media), often proceeds upwards to the middle of the hyoid bone, to which its apex is attached by loose fibrous tissue. Commonly this process lies somewhat to the left; occasionally it is thicker above than below, or is completely detached, or is split into two parts. Sometimes it appears to consist of fibrous tissue only, but often presents a reddish fibrous appearance, as if containing muscular fibres. According to Cruveilhier, the muscle described by Sœmmerring, under the name of the *levator glandulæ thyreoideæ* is nothing more than this process of the thyroid body. There can be no doubt, however, that in certain cases true muscular fasciculi, probably part of the thyro-hyoid muscle, descend from the hyoid bone to the thyroid gland or its pyramidal process. It sometimes, though rarely, happens that the isthmus is altogether wanting, the lateral lobes being then connected by cellular or fibrous tissue only.

The *weight* of the thyroid body varies ordinarily from one to two ounces. It is always larger in the female than in the male, and appears in the former to increase periodically about the time of menstruation. The thyroid body, moreover, is subject to much variation of size, and is, occasionally, the seat of enormous hypertrophy, constituting the disease called goitre. The *colour* of the thyroid body is of a dusky brownish red, but sometimes it presents a yellowish hue.

Structure.—The texture of this organ is firm and granular. It is invested with a thin transparent layer of dense cellular tissue, which connects it with the adjacent parts, surrounds and supports the vessels as they enter it, and imperfectly separates its substance into small masses of irregular form and size. This interstitial cellular tissue is free from fat.

When the thyroid body is cut into, a yellow glairy fluid escapes from the divided substance, which is itself found to consist of multitudes of minute closed vesicles, composed of a simple external capsular membrane, and containing a yellow fluid, with corpuscles resembling cell-nuclei and sometimes nucleated cells floating in it. These vesicles are surrounded by capillary vessels, and are held together in groups or imperfect lobules by areolar tissue. They vary in size from $\frac{1}{850}$th of an inch in diameter to that of a millet-seed, so as to be visible to the naked eye,—differing in size, however, in different individuals, more than in the same thyroid body. The *vesicles* are spherical, oblong, or flattened, and are perfectly distinct from each other; the *corpuscles*, according to Simon,* are in the fœtus and young subject disposed in close apposition and in a single layer on the inner side of the vesicles, but detach themselves in the progress of growth. The fluid coagulates by the action of heat or of alcohol, preserving, however, its transparency. According to the recent analyses, the substance of the thyroid body consists principally of albumen with traces

* Physiological Essay on the Thymus Gland, Lond. 1845, p. 78.

of gelatine, stearine, oleine, and extractive matter, besides alkaline and earthy salts and water. The salts are chloride of sodium, a little alkaline sulphate, phosphates of potash, lime, and magnesia, with some oxide of iron.

Vessels.—The *arteries* of the thyroid body are the superior and inferior thyroids of each side, to which is sometimes added a fifth vessel, named the *lowest* thyroid of Neubauer and Erdmann. The arteries are remarkable for their relative size, and for thèir frequent and large anastomoses; they terminate in a capillary network, upon the outside of the closed vesicles. The *veins*, which are equally large, ultimately form plexuses on the surface, from which a superior, middle, and inferior thyroid vein are formed on each side. The superior and middle thyroid veins open into the internal jugular; the inferior veins emanate from a plexus formed in front of the trachea, and open on the right side into the superior cava, and on the left into the brachiocephalic vein. The *lymphatics* of the thyroid body are extremely numerous and large, and indeed are supposed to be concerned in conveying into the blood the products formed within this organ.

Nerves.—The *nerves* are derived from the pneumogastric, and from the middle and inferior cervical ganglia of the sympathetic.

Development.—According to Mr. Goodsir,* the thyroid body is derived from, or rather is a remnant of, the blastodermic or germinal membrane, an origin which he also assigns to the thymus gland and suprarenal capsules. It may be easily recognised, he says, as distinct from the thymus by its more opaque and homogeneous appearance, and by its containing a larger quantity of vascular tissue round its component cells. According to the same observer, the superior and inferior thyroid arteries are derived respectively from the first and second primitive aortic arches. The transverse part is developed subsequently to the two lateral lobes. In the fœtus, and during early infancy, this organ is relatively larger than in after life; its proportion to the weight of the body in the new-born infant being 1 to 243 or 400, whilst at the end of three weeks it becomes only 1 to 1166, and in the adult 1 to 1800. (Krause.) In advanced life the thyroid body becomes indurated, and frequently contains earthy deposit; its vesicles also attain a very large size.

THE THYMUS GLAND.

The *thymus gland* or *body* (glandula thymus, corpus thymicum), is a temporary organ which reaches its greatest size at about the end of the second year, after which period it ceases to grow, and is gradually reduced to a mere vestige. When examined in its mature state in an infant under two years of age, it appears as a narrow elongated glandular-looking body, situated partly in the thorax, and partly in the lower part of the neck; lying, below, in the anterior mediastinal space, close behind the sternum, and in front of the great vessels, and reaching upwards upon the trachea in the neck. Its colour is grayish, with a pinkish tinge; its consistence is soft and pulpy, and its surface appears distinctly lobulated. It consists of *two lateral parts*, or *lobes*, which touch each other along the middle line, and are nearly symmetrical in form, though generally unequal in size, sometimes the left, and sometimes the right lobe being the larger of the two. Often an *intermediate lobe* exists between the two lateral ones, and occasionally the whole

* Philosoph. Transact. 1846.

body forms a single mass. The forms of the smaller lobules also differ on the two sides.

Each lateral lobe is of an elongated triangular form, its base being directed downwards. The *summit*, or upper extremity, usually mounts up into the neck, reaching above the sternum, as high as to the lower border of the thyroid body. The *base* rests on the upper part of the pericardium, to which it is connected by cellular tissue. The *anterior* surface, slightly convex, is covered by the first and the upper part of the second bone of the sternum, reaching, in the infant at birth, as low down as opposite the fourth costal cartilage. It is attached to the sternum by loose cellular tissue, but opposite the upper part of that bone is separated from it by the origins of the sterno-hyoid and sterno-thyroid muscles, which also cover it in the neck. The *posterior* surface, somewhat concave, rests, in the thorax, upon the front of the aortic arch, and the large arteries arising from thence, and also on the left innominate vein, some cellular tissue interposing between it and these parts. In the neck, it lies upon the front and corresponding side of the trachea, as high as the thyroid body. Its *external border* is in contact with the corresponding layer of the mediastinal pleura, near the internal mammary artery, and higher up (in the neck), with the carotid artery, or its sheath. The *internal* border is in close contact with that of the opposite lateral lobe. The dimensions of the thymus of course vary according to its stage of development. At birth it measures above two inches in length, an inch and a half wide below, and about three or four lines in thickness. Its weight at that period is about half an ounce. Its specific gravity, which is at first about 1·050, diminishes as the gland continues to waste.

Structure.—The thymus gland is surrounded by a proper investment of thin areolar tissue, which connects it with surrounding parts, and encloses in a common envelope the smaller masses which compose it. This being removed, the substance of the thymus is found to consist of numerous compressed lobules, connected by a more delicate intervening areolar tissue. These lobules vary in size from that of a pin's head to that of a pea. Each lobule, when divided, is seen to contain several membranous *cells* or *vesicles*. According to Sir Astley Cooper,* the cellular recesses of each lobule open into a small pouch at its base, which in turn communicates with a large elongated *central cavity* running through the corresponding lateral lobes of the gland—the vesicles, the pouches, and the central cavity, all containing a white fluid resembling chyle. This cavity, named by Sir A. Cooper the *reservoir of the thymus*, is represented by him as branching out into diverticula, around which the lobules are disposed, and is described as being lined by a vascular membrane, which is prolonged through the diverticula and pouches into the cells. Moreover, the lobules themselves are said to be held together by a strong band, around which they are attached like knots upon a rope, which is itself arranged spirally around the common central cavity. The existence of a continuous central cavity, containing a chylous fluid, is doubted by Henlé, and denied by Berres, Bischoff, and Haugstedt, who think that the vesicles are perfectly closed, and independent of each other.

* Anatomy of the Thymus Gland. London, 1832.

Mr. Goodsir is of opinion that this common cavity results from the mode of preparation, by the distension and separation of contiguous lobules which adhere only slightly together, whilst the entire glandular mass is enveloped in a strong cellular capsule. Meckel, Tiedemann, and Huschke recognise the presence of a cavity, which, according to the latter, is most distinctly seen in well-nourished children, in whom it is distended with a white fluid. Mr. Simon, who by his recent investigations has shown that the primitive form of the thymus gland is a linear tube, from which, as it grows, lateral branched diverticula subsequently bud out, states, that in the mature thymus, this tube becomes obscure; that the central cavity described and figured by Sir A. Cooper is too large, owing to over-distension; but, nevertheless, that all the parts of each lateral lobe of the thymus do depend on a single common cavity, and that even the terminal vesicles communicate with it by means of the numerous diverticula. The central cavity has no outlet, and the thymus gland has no excretory duct.

The walls of the ultimate vesicles are formed of simple homogeneous membrane; they are surrounded by a network of fine capillary vessels, and are supported by a delicate cellular tissue, containing some elastic fibres. The *white fluid* found in the vesicles and interior of the thymus is particularly abundant in stout healthy infants, but scanty in opposite conditions. It contains numerous corpuscles, closely resembling the pale blood-corpuscles and those found in the chyle and in the juice of the lymphatic glands. The milky character of the thymic fluid is owing to the presence of these corpuscles, and not of minute molecules as is the case with the chyle. The corpuscles are either flattened circular discs or spherical bodies, varying in diameter from $\frac{1}{2500}$th to $\frac{1}{5000}$th of an inch. They contain a nucleus, composed itself of from one to three, or even four, dark clear granules. According to the observations of Mr. Gulliver, the action of reagents upon the corpuscles of the fluid of the thymus is precisely similar to that upon the corpuscles of the chyle and lymph.

Vessels.—The *arteries* are derived from various sources, viz., from the internal mammary arteries, the inferior and superior thyroid, the subclavian and carotid arteries. They terminate in capillary vessels, which form a vascular envelope around each vesicle.

The *veins* pursue a different course from the arteries, and, for the most part, open into the left innominate vein.

The *lymphatics* are large, but their course has not been well studied. Sir A. Cooper succeeded in injecting them only once in the human subject. According to Simon, they may be traced through the gland, but do not arise from its cavity; they terminate in the thoracic duct, or in the right lymphatic duct. It is probable that they are concerned in conveying into the blood the products formed in the substance of the thymus.

The *nerves* are very minute. Haller thought they were partly derived from the phrenic nerves, but, according to Sir A. Cooper, no filaments from these nerves go into the gland, though, as well as a branch from the descendens noni, they reach the investing capsule. Small filaments, derived from the pneumogastric and sympathetic nerves, descend on the thyroid body, to the upper part of the thymus.

Sympathetic nerves also reach the gland along its various arteries, especially on the thymic branch of the internal mammary artery.

Chemical Composition.—The substance and fluid of the thymus contain nearly eighty per cent. of water. Its solid animal constituents are composed essentially of albumen and fibrin in large quantities, mixed with gelatine and other animal matter. The salts are principally alkaline and earthy phosphates, with chloride of potassium. It contains, therefore, no constituents especially rich in carbon.

Development.—According to Mr. Goodsir,* the thymus gland, like the thyroid body, is essentially a highly-developed remnant of the blastodermic membrane, the use of which, both originally and as thus modified, he conceives to be to prepare material for nutritive purposes. At first, according to his statement, the thyroid and thymus are not distinguishable from each other, but soon they become separated by the absorption of a part between them.

The early development of the thymus has been carefully studied by Mr. Simon,† whose researches were chiefly conducted in the embryos of swine and oxen. In embryos, about half an inch in length, it may be seen by the aid of a high power; and in those of one and a half inch, by the aid of a simple lens. When first distinguishable, it consists of a simple tube closed in all directions, lying along the carotid vessels. The contents of this tube are granular, but do not show regular corpuscles; its walls are delicate and homogeneous. The tube has no connexion with the respiratory mucous membrane, as was supposed by Arnold; and, so soon as it is discoverable, it is found to be perfectly distinct from the thyroid body. At intervals along the sides of this tube small vesicles bud out, so as to form lateral diverticula, which contain nucleated corpuscles, and which go on subsequently branching out by twos or fours,—the formation of the permanent vesicles being merely the last repetition of this process. In the human fœtus, at about the ninth week the thymus consists of two minute elongated parallel parts, lying chiefly on the upper part of the pericardium, and presenting under the microscope a distinct tubulo-vesicular structure; it then increases rapidly until birth, but not equally, for it grows especially during the seventh, eighth, and ninth months of intra-uterine existence.

After birth, the thymus, as already stated, continues to grow to near the end of the second year. According to the observations of Haugstedt and Simon upon the weight of this organ in young animals, it appears for a short time after birth to increase not merely absolutely, but even faster than the rest of the system, and during the next period only to keep pace with the increase of the body. After the second year it ceases to grow, and becomes gradually converted by the eighth or twelfth year into a fatty mass. In this condition the corpuscles of the thymus disappear, forming, according to Simon's opinion, the nuclei of cells which become developed into the cells of adipose tissue. At puberty the thymus is reduced to a mere vestige, losing its original structure entirely, and consisting of brownish tissue found in the upper part of the anterior mediastinum. Traces of it, however, have been found at the twentieth or twenty-fifth year, and, as an extreme exception, at the age of thirty.

The thymus gland presents no difference in the two sexes. It exists, according to Simon, in all animals breathing by lungs, and is persistent in those which hibernate, though only as a mass of fat.

Function.—The functions of the thymus gland are not known. It was supposed by Hewson, on the ground of the identity between the thymic and lymph particles, that this organ is an appendage to the lymphatic system, and that its particles are concerned in the formation of the blood globules. Others have conceived that its office was in some way to prepare a nutritive fluid for the system of the fœtus and early infant. Mr. Simon concludes, that the thymus is intended to set aside from the blood a reserve of oxidizable material available for respiration, at a period of life when but a scanty supply of respirable matter is derived from the wear of the muscular tissue.

* Loc. cit. Philos. Trans. 1846. † Op. cit.

NEUROLOGY.

NERVOUS SYSTEM.

Of the functions performed through the agency of the nervous system, some are entirely corporeal, whilst others involve phenomena of a mental or psychical nature. In the latter and higher class of such functions are first to be reckoned those purely *intellectual operations*, carried on through the instrumentality of the brain, which do not immediately arise from an external stimulus, and do not manifest themselves in outward acts. To this class also belong *sensation* and *volition*. In the exercise of sensation the mind becomes conscious, through the medium of the brain, of impressions conducted or propagated to that organ along the nerves from distant parts; and in voluntary motion a stimulus to action arises in the brain, and is carried outwards by the nerves from the central organ to the voluntary muscles. Lastly, *emotion*, which gives rise to gestures and movements varying with the different mental affections which they express, is an involuntary state of the mind, connected with some part of the brain, and influencing the muscles through the medium of the nerves.

The remaining functions of the nervous system do not necessarily imply any participation of the mind. In the production of those movements, termed *reflex*, *excited*, or *excito-motory*, a stimulus is carried along afferent nerve-fibres to the brain, or spinal cord, and is then transferred to efferent or motor nerve-fibres, through which the muscles are excited to action; and this takes place quite independently of the will, and may occur without consciousness. The motions of the heart, and of other internal organs, as well as the invisible changes which occur in secretion and nutrition, are in a certain degree subject to the influence of the nervous system, and are undoubtedly capable of being modified through its agency, though, with regard to some of these phenomena, it is doubtful how far the direct intervention of the nervous system is necessary for their production. These actions, which are all strictly involuntary, are, no doubt, readily influenced by mental emotions; but they may also be affected through the nerves, in circumstances which entirely preclude the participation of the mind.

The nervous system consists of a *central part*, or rather a series of connected *central organs*, named the *cerebro-spinal axis*, or *cerebro-spinal centre*; and of the *nerves*, which have the form of cords connected by one extremity with the cerebro-spinal centre, and extending

from thence through the body to the muscles, sensible parts, and other organs placed under their control. The nerves form the medium of communication between these distant parts and the centre; one class of nervous fibres, termed *afferent* or *centripetal*, conducting impressions towards the centre,—another, the *efferent* or *centrifugal*, carrying motorial stimuli from the centre to the moving organs. The nerves are, therefore, said to be internuncial in their office, whilst the central organ receives the impressions conducted to it by the one class of nerves, and imparts stimuli to the other,—rendering certain of these impressions cognizable to the mind, and combining in due association, and towards a different end, movements, whether voluntary or involuntary, of different, and often of distant parts.

Besides the cerebro-spinal centre and the nervous cords, the nervous system comprehends also certain bodies named *ganglia*, which are connected with the nerves in various situations. These bodies, though of much smaller size and less complex nature than the brain, agree, nevertheless, with that organ in their elementary structure, and to a certain extent also in their relation to the nervous fibres with which they are connected; and this correspondence becomes even more apparent in the nervous system of the lower members of the animal series. For these reasons, as well as from evidence derived from experiment, but which as yet, it must be confessed, is of a less cogent character, the ganglia are regarded by many as nervous centres, to which impressions may be referred, and from which motorial stimuli may be reflected or emitted; but of local and limited influence as compared with the cerebro-spinal centre, and operating without our consciousness and without the intervention of the will.

The nerves are divided into the *cerebro-spinal*, and the *sympathetic* or *ganglionic* nerves. The former are distributed principally to the skin, the organs of the senses, and other parts endowed with manifest sensibility, and to muscles placed more or less under the control of the will. They are attached in pairs to the cerebro-spinal axis, and like the parts which they supply are, with few exceptions, remarkably symmetrical on the two sides of the body. The sympathetic or ganglionic nerves, on the other hand, are destined chiefly for the viscera and blood-vessels, of which the motions are involuntary, and the natural sensibility is obtuse. They differ also from the cerebro-spinal nerves in having generally a grayish or reddish colour, in their less symmetrical arrangement, and especially in the circumstance that the ganglia connected with them are much more numerous and more generally distributed. Branches of communication pass from the spinal and several of the cerebral nerves at a short distance from their roots, to join the sympathetic, and in these communications the two systems of nerves mutually give and receive nervous fibres.

The nervous system is made up of a substance proper and peculiar to it, with inclosing membranes, cellular tissue, and blood-vessels. The *nervous substance* has been long distinguished into two kinds, obviously differing from each other in colour, and therefore named the *white*, and the *gray* or *cineritious*.

CHEMICAL COMPOSITION.

The information we possess respecting the chemical composition of nervous matter is for the most part founded on analyses of portions of the brain and spinal cord; but the substance contained in the nerves, which is continuous with that of the brain and cord, and similar in physical characters, appears also, as far as it has been examined, to be of the same general chemical constitution. No very careful comparative analysis has yet been made of the gray and white matter, to say nothing of the different structural elements of the nervous substance; and indeed it must be remembered, that, in portions of brain subjected to chemical examination, capillary blood-vessels, and perhaps other accessory tissues, are mixed up in greater or less quantity with the true nervous matter, and must so far affect the result.

The nervous matter may be said to consist of albumen dissolved in water, and combined with fatty principles and salts. The water, which forms four-fifths of the whole cerebral substance, may be removed by immersion in alcohol and evaporation. When the solid matter which remains, after removal of the water, is treated with ether and hot alcohol, the fatty compounds are extracted from it by these menstrua, and there remains a mixture of coagulated albumen and salts with a small amount of accessory tissues, chiefly vessels.

According to Vauquelin, the human brain contains in one hundred parts, water, 80, albumen 7, white fat 4·55, red fat 0·7, osmazome 1·12, phosphorus 1·5, acids, salts, and sulphur 5·15. Of the fat, cholesterine, the properties of which have been already stated, vol. i. p. 48, forms a large part. The remainder may, according to Couerbe, be resolved into, 1. *Cerebrot*, an unsaponifiable and difficultly fusible fat like cholesterine; 2. *Eleencephol*, a reddish oil which readily dissolves the other cerebral fats; 3. *Cephalot;* and 4. *Stearo-conot*, two solid saponifiable fats of a yellow colour, differing in fusibility, and in their solubility in ether. Couerbe states, that these four fatty compounds contain, in addition to the usual elements of such substances, also nitrogen, sulphur, and phosphorus.

Frémy, who has since investigated the subject, represents the cerebral substance as consisting of 80 per cent. of water, 7 of albumen, and 5 of fatty constituents. These last are, 1. *Cerebric acid*, which is the most abundant; 2. *Cholesterine;* 3. *Oleophosphoric acid;* and 4. Olein, Margarin, and traces of their acids. The properties of most of these fats have been already noticed (vol. i. p. 47). Frémy denies that they contain sulphur as a constituent, and he ascribes the presence of that ingredient to an admixture of albumen. He finds that the oleophosphoric acid is a very unstable compound, and that under the influence of slight causes it is readily transformed into phosphoric acid and olein. According to the same inquirer, the fat contained in the brain is confined almost entirely to its white substance, which loses its characteristic white aspect when the fat has been extracted. The spinal cord and nerves yield the same constituents as the brain; but the cord is said by Vauquelin to contain a larger proportion of fat; and, according to L'Heritier, the nerves contain more albumen, and less of solid, but more of soft fat, than the brain.

STRUCTURAL ELEMENTS.

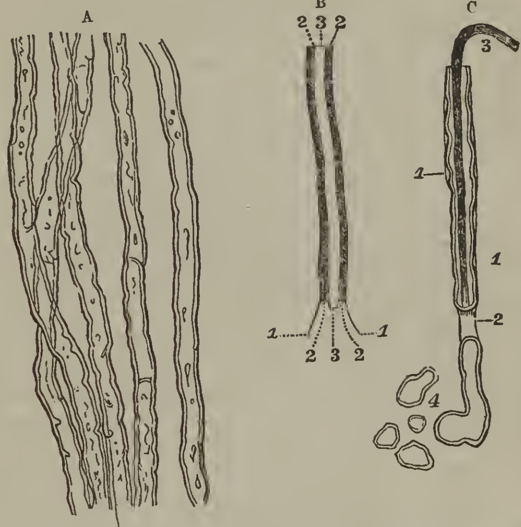
When subjected to the microscope, the nervous substance is seen to consist of two different structural elements, viz., *fibres*, and *cells* or *vesicles*. The fibres are found universally in the nervous cords, and they also constitute the greater part of the nervous centres; the cells or vesicles on the other hand are confined in a great measure to the latter, and do not exist in the nerves properly so called, unless it be at

their peripheral expansions of some of the organs of special sense; they are contained in the gray portion of the brain, spinal cord, and ganglia, which gray substance is in fact made up of these vesicles intermixed in many parts with fibres, and with a variable quantity of granular or amorphous matter.

In further pursuing the subject, we shall first examine the fibres and vesicles by themselves, and afterwards consider the structure of the parts which they contribute to form, viz., the cerebro-spinal organs, the ganglia, and the nerves.

The fibres are of two kinds: the *tubular* or *white*, and the *gelatinous* or *gray*; the former are by far the most abundant; the latter are found

Fig. 311.



A. Tubular nerve-fibres, showing the sinuous outline and double contours.
B. Diagram to show the parts of a tubular fibre, viz., 1, 1, *membranous tube.* 2, 2, *white substance* or *medullary sheath.* 3, *axis* or *primitive band.*
C. Figure (imaginary) intended to represent the appearances occasionally seen in the tubular fibres. 1, 1, membrane of the tube seen at parts where the white substance has separated from it. 2, a part where the white substance is interrupted. 3, axis projecting beyond the broken end of the tube. 4, part of the contents of the tube escaped.

principally in the sympathetic nerve, but are known to exist also in many of the cerebro-spinal nerves.

*The Tubular Fibres.**—These form the white part of the brain, spinal cord, and nerves. When collected in considerable numbers, and seen with reflected light, the mass which they form is white and opaque. Viewed singly, or few together, under the microscope, with transmitted light, they are transparent; and if quite fresh from a newly killed animal, and unchanged by cold or exposure, they appear as if entirely homogeneous in substance, like threads of glass, and are

* Also named "white fibres" and "nerve tubules:" I prefer the term "tubular fibres," first used, so far as I know, by Dr. Todd.

bounded on each side by a simple and usually gently sinuous outline. Their size differs considerably even in the same nerve, but much more in different parts of the nervous system; some being as small as the $\frac{1}{12000}$ and others upwards of the $\frac{1}{1500}$ of an inch in diameter; and the same fibre may change its size in different parts of its course. Very speedily after death, and especially on exposure to the action of water, these seemingly homogeneous fibres become altered; and it is when so altered that they are commonly subjected to examination, as represented in fig. 311, A. In particular instances, and in favourable circumstances, it may be discovered that the fibre is composed of a fine membranous tube, enclosing a peculiar soft substance, and that this contained substance itself is distinguishable into a central part placed like a sort of axis in the middle of the tube, and a peripheral portion surrounding the axis, and occupying the space between it and the tubular inclosing membrane. In the annexed ideal plan, (fig. 311, B,) the *membranous tube* is marked 1, 1: the central part, marked 3, was named *cylinder axis* by Purkinje, who considered it to be identical with the structure previously described by Remak under the name of the *primitive band* (fibra primitiva); the matter surrounding it, marked 2, 2, is supposed to be the chief cause of the whiteness of the brain and nerves, and it was accordingly named the *white substance* by Schwann, and by others, though less appropriately, the *medullary sheath*. It is this last-mentioned substance which undergoes the most marked change on exposure; it then seems to suffer a sort of coagulation or congelation, and, when this has taken place, it very strongly refracts the light, and gives rise to the appearance of a shaded border on each side of the nerve-tube (fig. 311, A and C). This border, though darker than the rest of the tube, is nevertheless translucent, and is either colourless, or appears of a slightly yellowish or brownish tint; it is bounded by two nearly parallel lines, so that the nerve-fibre has then a double contour, and the inner line gradually advances further inwards as the change in the white substance extends to a greater depth. These parallel lines pursue a sinuous course, often with deep and irregular indentations: while straight or curved lines of the same character, occasioned no doubt by wrinkles or creases in the layer of white substance, are frequently seen crossing the tube. By continued exposure, round and irregular spots appear at various points, and at length the contents of the nerve-tube acquire a confusedly granular aspect.

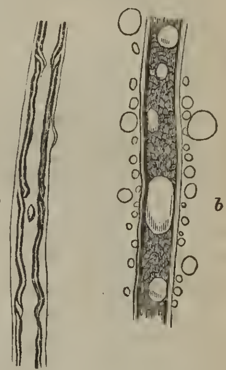
The double contour appears only in fibres of a certain size; in very fine tubes, which become varicose or dilated at intervals, the double line is seen only in the enlargements, and not in the narrow parts between. It often happens that the soft contents of the tube are pressed out at the ruptured extremities, as in fig. 311, C 4, and then the round or irregular masses of the effused matter are still surrounded by the double line, which proves that this appearance is produced independently of the membranous tube. So long as this tube is accurately filled by the contained matter, its outline cannot be distinguished; but sometimes, when the white substance separates at various points from the inside of the tube, the contour of the fibre becomes indented and irregular, and then the membrane of the tube may, in favourable circumstances, be discerned as an extremely faint line, running outside the deeply shaded border formed by the white substance, and taking no part in its irregular sinuosities (fig. 311, C, 1, 1). The membranous tube may also be distinguished at parts where the continuity of its contained

matter is broken in consequence of traction, squeezing, or such like injury of the fibre; in such parts the double line produced by the white substance is wanting, and the faint outline of the membranous tube may be perceived passing over the interruption (2). The fine transparent membrane which forms this tube appears to be quite simple and homogeneous in structure.

The *axis* is situated in, or near, the middle of the nerve-tube, where it may occasionally be seen, on a careful inspection, as a transparent stripe or band, bounded on either side by a very faint even outline, having no share in the sinuosities of the white substance (fig. 311, c).

The axis seems to be of a more tenacious consistence than the white substance, and may accordingly be sometimes seen projecting beyond it at the end of a broken nerve-tube, either quite denuded, or covered only by the tubular membrane, the intervening white substance having escaped. Although the name of axis cylinder would seem to imply that it had actually a cylindrical figure, yet this is by no means certain; and whether naturally cylindrical or not, it certainly very generally appears more or less flattened when subjected to examination. One writer (Hannover*) is inclined to think that it is hollow, and that it collapses into a flat band when exposed; but this is not probable. It sometimes appears striated longitudinally, and it has been observed even to split into finer filaments. Others have conceived that the soft matter contained in the nerve-tube is of uniform nature throughout, and that the axis is nothing more than a portion of this substance in the centre, which has remained unchanged whilst the superficial and more exposed part has become coagulated; a supposition difficult to reconcile with the fact that the axis often appears more consistent, at least more tenacious, than the enveloping white substance. It seems on the whole more probable that there is an original difference of material between the central and peripheral part of the nerve-pulp, and that the effect of exposure is to render the difference more conspicuous. The nerve-pulp, as already stated, is in its chemical constitution an oleo-albuminous compound; and there seems some reason to think that the oleaginous constituent is represented entirely by the white substance; for whilst water, especially when cold, rapidly produces congelation of that substance, [fig. 312, a,] ether on the other hand causes it speedily to disappear as if by solution, and globules of oil afterwards make their appearance both within and without the tube, its remaining contents becoming granular [fig. 312, b].

[Fig. 312.



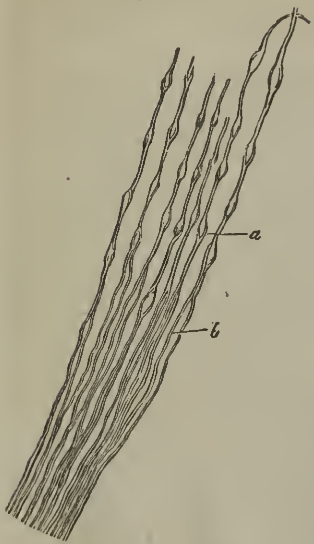
Nerve-tubes of the common eel:—*a*. In *water*. The delicate line on its exterior indicates the tubular membrane. The dark, double-edged inner one is the white substance of Schwann, slightly wrinkled. *b*. The same in *ether*. Several oil-globules have coalesced in the interior, and others have accumulated around the exterior of the tube. The white substance has in part disappeared.—Magnified 300 diameters.—Todd and Bowman.]

Many of the tubular nerve-fibres, when subjected to the microscope, appear dilated or swollen out at short distances along their length, and contracted in the intervals between the dilated parts. Such fibres have been named *varicose* (fig. 313). They occur principally in the brain and spinal cord, and in the intracranial part of the olfactory, in the optic, and acoustic nerves; they are occasionally met with also in the other nerves, especially in young animals. These fibres, however, are naturally cylindrical like the rest, and continue so while they remain undisturbed in their place; and the varicose character is occasioned by pressure or traction during the manipulation, which causes

* Recherches microscopiques sur le Système Nerveux, 1844, p. 29.

the soft matter contained in the nerve-tube to accumulate at certain points, while it is drawn out and attenuated at others. Most probably the change takes place before the nerve-pulp has coagulated. The fibres in which it is most apt to occur are usually of small size, ranging from $\frac{1}{12000}$ to $\frac{1}{3600}$ of an inch in diameter; and when a very small fibre is thus affected, the varicosities appear like a string of globules held together by a fine transparent thread. As already remarked, the double contour caused by congelation of the white substance does not appear in the highly constricted parts. Hannover states that the axis may sometimes be seen running through the varicosities and undergoing no corresponding dilatation.

Fig. 313.

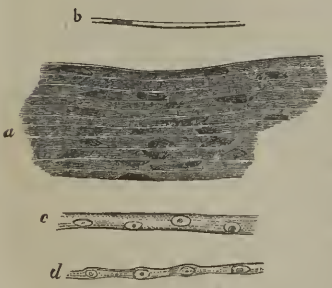


Fibres from the root of a spinal nerve. At *b*, where they join the spinal cord, they are varicose; lower down, at *a*, they are uniform and larger.—(Valentin.)

Neither in their course along the nervous cords, nor in the nervous centres, have these tubular fibres ever been observed to unite or anastomose together, nor are they seen to divide into branches; it is therefore fair to conclude that, though bound up in numbers in the same nervous cords, they merely run side by side like the threads in a skein of silk, and that they maintain their individual distinctness from one end to the other. They, however, divide in some cases at their peripheral terminations.

Of the Gelatinous Fibres.—These, which have also been named "organic" or "gray" nerve-fibres (fig. 314), exist in great numbers in the sympathetic nerve, and are also found in many of the cerebro-spinal nerves, but for the most part in much smaller proportion. In both cases they are associated with tubular or white fibres, and they give a gray colour to those nervous cords in which they predominate. There is some doubt as to the real nature of these gelatinous fibres; several anatomists, whose opinion is deservedly held in high estimation, denying that they are true nerve-fibres, and maintaining that they belong to the class of enveloping structures, and are allied in nature and office to the fibres of cellular tissue. In their microscopic characters they bear a strong resemblance to the plain muscular fibres, but are of smaller average breadth, their diameter measuring from $\frac{1}{6000}$ to $\frac{1}{4000}$

Fig. 314.

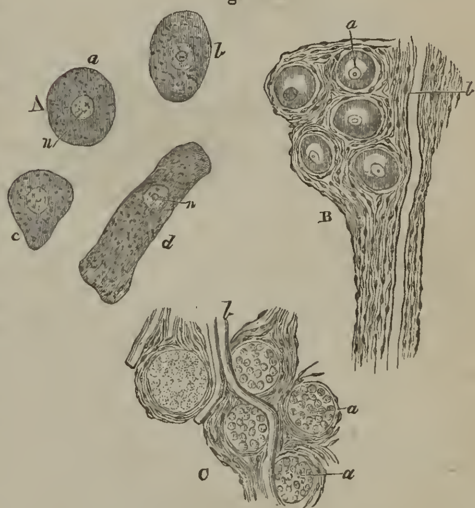


Gelatinous nerve-fibres. (*a* and *b* magnified 340 diameters, after Hannover; *c* and *d* after Remak.)

of an inch. They are flattened, translucent, and apparently homogeneous, or at most faintly granular, with numerous corpuscles resembling cell-nuclei lying on them. Of these nuclei some are round, and many oval or fusiform, lying with their long diameter in the direction of the fibres; many contain one or more nucleoli. These fibres seem to be of rather tenacious consistence, and are difficult to separate from one another; some observers describe them as being sometimes split at their ends into smaller filaments.

Nerve-cells or *Nerve-vesicles.*—These, as already mentioned, constitute the second kind of structural elements proper to the nervous system. They are found in the gray matter of the cerebro-spinal centre and ganglions, constituting a principal part of the last-mentioned bodies, and thence often named *ganglionic corpuscles* or *ganglion-globules;* they exist also in some of the nerves of special sense. The most characteristic form in which the *nerve-cells* present themselves is that of a vesicle, constructed of a fine, simple, transparent cell-membrane, filled with granular matter, and containing a vesicular nucleus, with one or more nucleoli. They differ greatly from one another in size; some being scarcely larger than a human blood-corpuscle, others $\frac{1}{300}$ of an inch or upwards in diameter. The greater number are spheroidal in figure, especially those found in the ganglia (fig. 315, A, *a*, *b*), but they are often more or less angular, oblong, or irregular (*c*, *d*), especially when they have been closely packed; and they are liable, too, to become altered and distorted in shape, in the process of extracting and insulating them. But many of the nerve-cells, especially those from the gray matter of the spinal cord, and certain parts of the encephalon, present a very remarkable modification of figure, being drawn out at one or more points of their circumference into long filamentous processes (fig. 316); and these nerve-cells, like other nucleated cells which present this peculiarity, are usually named "caudate." Many of them are of a pyriform shape, with their small end produced into a slender process, either simple or branched at its

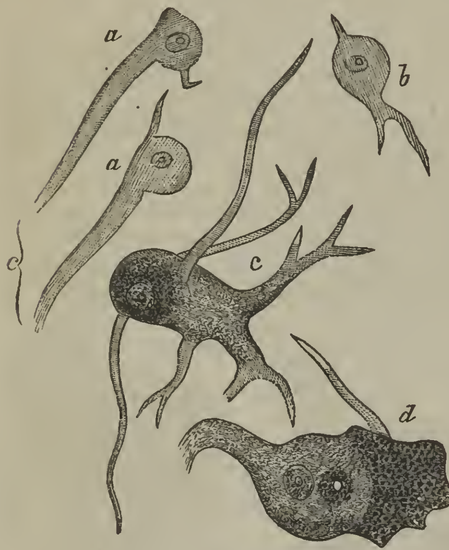
Fig. 315.



A. Ganglionic nerve-cells detached.
B and C. Small portions of ganglion, in which the nerve-cells are seen imbedded among the gelatinous fibres. In C they are still covered by their capsule of nucleus-like corpuscles, (*a*, *a*.) Tubular fibres (*b*, *b*,) are seen passing through the ganglion; *n* indicates the nucleus of the nerve-cells in all the figures.—(From Valentin.)

extremity (fig. 316, *a*, *c*); others send out several such processes from different points. These processes are formed of extensions of the cell-membrane, with its inclosed granular matter, and have a corresponding delicacy of structure, so that they frequently break off at a short distance from the vesicle; they are described by several observers as being prolonged into the nerve-fibres, as will hereafter be more particularly referred to. Sometimes, especially in young animals, a short process extends in form of a commissure from one cell to another. The *nucleus*, (figs. 315, *n*, and 316,) which takes no share in the caudate prolongations of the cell-wall, is evidently also of a vesicular structure; it has an eccentric position, and a very regular round or oval outline, usually much more strongly marked than that of the nerve-cell itself; its size, too, is less variable. Sometimes, though rarely, a cell contains two nuclei. The *nucleolus* appears like a bright speck within the nucleus; it varies a good deal in size, being in many cases as large as a human blood-particle, and sometimes considerably larger; it would also seem to be a vesicular body. There may be two or three nucleoli in one nucleus. The matter which fills the nerve-cell is usually finely granular, and slightly tinged throughout with a brownish-red colour; and cells are often seen, especially those of the large caudate kind, with one, or sometimes two, much deeper coloured brown patches, caused by groups of pigment-granules (fig. 316, *c*, *d*): the colour is deeper in adult age than in infancy.

[Fig. 316.

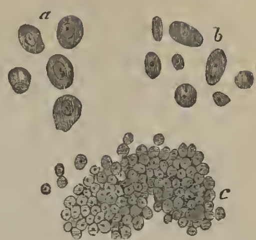


Ganglion globules, with their processes, nuclei, and nucleoli:—*a. a.* From the deeper part of the gray matter of the convolutions of the cerebellum. The larger processes are directed towards the surface of the organ. *b.* Another from the cerebellum. *c. d.* Others from the post. horn of gray matter of the dorsal region of the cord. These contain pigment, which surrounds the nucleus in *c.* In all these specimens the processes are more or less broken.—Magnified 200 diameters.—Todd and Bowman.]

Other nerve-cells (fig. 317, *a*) are found in the nervous substance, which are distinguished chiefly by the pellucid, colourless, and homogeneous aspect of the matter contained in them; such cells possess a nucleus like the rest; they are seldom large, and have usually a simple round or oval figure. They occur along with nerve-cells of the kind before described, and are perhaps merely an earlier condition of these. Lastly, small vesicular bodies, of the size of human blood-corpuscles

and upwards, containing one or more bright specks like nucleoli, abound in the gray matter in certain situations (fig. 317, *b*, *c*). These bodies are exactly like the nuclei of the nerve-cells already described, and some of them may perhaps be really such nuclei escaped from cells crushed and broken down in the manipulation; but, looking to their numbers and dense array in certain regions (fig. 317, *c*), their presence cannot well be generally referred to this cause, and it comes then to be a question whether they are free nuclei destined to become enclosed in a cell of subsequent formation, or actually cells in which the cell-wall lies close to the nucleus, and cannot be distinguished from it. These nucleus-like corpuscles are very abundant in the superficial gray matter of the cerebellum.

Fig. 317.



a, cells from the (cortical) gray matter of the brain. *b* and *c* are from the cortical substance of the cerebellum; *b* resemble detached cell-nuclei. *c* are smaller bodies, also like cell-nuclei, densely aggregated.—(After Hannover, magnified 340 diameters.)

In the gray matter of the cerebro-spinal centre, the nerve-cells are usually imbedded in a sort of matrix of granular substance, which is interposed between them in greater or less quantity, and is very generally traversed by nerve-fibres. In the ganglia, properly so called, the cells are packed up among nerve-fibres, chiefly of the gelatinous kind; but each cell is also immediately surrounded by a coating or capsule formed of gelatinous fibres, and a layer of granular corpuscles, not unlike the most common kind of granular cell-nuclei, united together by a pellucid substance (fig. 315, c, *a*, *a*).

Such being the structural elements of the nervous substance, we have next to consider the arrangement of these cells and fibres in the organs which by their combination they form; namely, the spinal cord, the encephalon, the ganglia, and the nerves.

CEREBRO-SPINAL CENTRE.

In the spinal cord, the gray matter is situated in the middle; the white substance, which is in larger quantity, surrounding and inclosing the gray. In the encephalon, the white part also predominates in mass, and incloses large internal deposits of gray substance; but a very large amount of the latter is spread over the white, on the convoluted surface of the brain and cerebellum, and is thence named the cortical substance. Both kinds of matter receive blood-vessels, but the gray is greatly more vascular than the white.

Gray part of the spinal cord.—The gray part of the cord, as elsewhere described, represents in a transverse section two lateral crescents, with their cornua averted and their convexities connected across the median plane by a gray commissure. The posterior horns of this bicrescentic figure consist, towards their points, of a peculiar variety of gray matter, named *gelatinous* by Rolando, who appears

first to have distinguished it: the remaining and greater part of the gray substance is of the kind most generally prevalent, and was named by Rolando the *spongy substance.* Remak* describes the gelatinous substance as passing along the posterior part of the posterior cornua, and then across from one side of the cord to the other, so as to form the back part of the gray commissure.

Examined with the microscope, the gray matter of the cord is found to consist of the following elements, viz.

1. Large caudate nerve-cells, such as those represented in fig. 316. These are, in a great measure, confined to the spongy substance, but, according to Hannover,† are also met with, though sparingly, in the gelatinous part. They lie imbedded among fibres, to be presently noticed, with a certain amount of the usual granular matrix. Most of them belong to the class of largest-sized nerve-cells; they contain large nuclei, and often collections of dark-coloured pigment, and most are furnished with several very long simple or branched processes, which traverse the intervening space in various directions.

2. Pale fibres. The gelatinous substance is described by Remak as being principally made up of fibres of this kind, which run longitudinally, and in very dense order; he finds similar fibres also in the spongy substance, where, however, they are much obscured by other structures. From their resemblance to the filamentous processes of the caudate nerve-cells, it has been conjectured that they may be in reality prolonged from these appendages; but this view is not free from objection. These pale fibres are beset with numerous corpuscles resembling common cell-nuclei, and Remak states that in young animals these apparent nuclei, or other nuclear corpuscles like them, are inclosed in pellucid colourless cells.‡ It must be remembered that the capillary vessels, which are very numerous in the gray matter, are covered with corpuscles of the same description as those above mentioned.

3. Tubular fibres. Such fibres exist abundantly both in the spongy and gelatinous substance, but more so in the former. Their arrangement, and their relations to the other structures in the gray matter, are not fully known; they are continued from the white substance, and, in part at least, belong to the roots of the spinal nerves, with which they will presently be further considered.

White part of the cord.—The white substance of the cord consists of tubular fibres, of smaller average size than those of the nerves, and apparently of more delicate structure, for they readily become varicose. They are collected into bundles and laminæ, between which lie vessels and a few fibres of cellular tissue, and hence the fibrous and lamellar character visible in the white substance to the naked eye. The general direction of the fibres is longitudinal, but some are described as passing obliquely or directly across in the commissures from one half of the cord to the other; the exact extent and connexions of these

* De Systematis Nervosi Structura, Berol. 1838, p. 12.
† Recherches microscopiques sur le Système Nerveux. Copenhague et Paris, 1844.
‡ Müller's Archiv. 1841, p. 514.

crossing fibres have not been made out. Of the longitudinal fibres, some are continued into the roots of the spinal nerves; but this does not appear to be the case with all; for it seems probable that there are fibres which, without passing into the nerves, extend longitudinally from one part of the cord to another, uniting the gray matter of its different regions, and connecting also the upper part of the cord with the cerebellum, medulla oblongata, and cerebrum.

The root of each spinal nerve, as will be more fully described hereafter, is attached to the white part of the cord by one portion of its fibres, whilst the remainder pass horizontally, or with a slight upward obliquity, into the gray matter. The former set of fibres can be shown to be continuous with longitudinal fibres of the cord, which are said to descend at first vertically, and then to take a slanting direction towards the surface, where they are continued into the root of the nerve. Whether these longitudinal fibres, thus continuous below with the nerves, are all connected by their upper extremity with the encephalon, as is most commonly believed, or whether they take their rise, in whole or in part, in the gray substance of the upper region of the cord, as some think, must still be considered doubtful. The fibres of the cord, in passing into the nerve, put off their varicose character, and increase in size, as shown in fig. 313. Those fibres of the nerve-roots which are traced into the gray matter, are supposed by some anatomists (*e. g.* Valentin) merely to pass through that substance, and then to ascend in the white part of the cord; but from a consideration of the comparative thickness of the cord at different heights, and of the structure of what are deemed analogous parts of the nervous system in invertebrate animals, as well as for reasons derived from physiological phenomena, it is more generally thought that the nervous fibres in question take their origin in the gray matter.

As to the manner in which this takes place, as indeed respecting the mode of origin of nerve-fibres generally, there are two very different views. Some suppose that when nerve-fibres arise or terminate in gray matter, they form loops or slings, which lie among the nerve-cells and other elements of that substance, each loop of course corresponding to two fibres in the nerve; according to others, the fibres arise from the caudate nerve-cells, being merely prolongations of the filamentous processes issuing from these bodies, which, after proceeding a little distance from the cell, acquire the character of tubular fibres. Admitting the probable origin of nerve-fibres in the gray substance, still, from the uncertainty, or, at any rate, the acknowledged difficulty of all observations on the subject, the precise mode in which they are related to its elements can scarcely be considered as fully determined; although the testimony of many competent observers, who declare that they have been able unequivocally to trace the continuity of nerve-fibres with the nerve-cells,* leaves no longer room to doubt that that is at least one mode in which they arise.

White part of the encephalon.—The white matter of the encephalon consists of tubular fibres, in general still smaller than those of the cord, and still more prone to become varicose. The general direction

* Helmholz and Will in invertebrate animals; Kölliker in the frog; and Hannover in all classes of vertebrata, as well as in several invertebrata. In the electric lobes of the brain of the torpedo, by Harless, who states that he found the nerve-fibre to be connected with the nucleus of the cell. Also Robin and Wagner in the ganglia of various cartilaginous fishes.

which they follow is best seen in a brain that has been hardened by immersion in spirits, although it is true that we do not then trace the single fibres, but only the fine bundles and fibrous lamellæ which they form by their aggregation; and a detailed account will be given elsewhere of their course and apparent connexions, as far as has been made out in this manner.

It may suffice here to remark, that one large body of fibres can be traced upwards from the spinal cord to the gray matter situated in different regions of the encephalon; some of these fibres reaching as high as the cortical layer on the surface of the cerebrum and cerebellum, others apparently terminating in the corpus striatum, thalamus opticus, corpora quadrigemina, and other special deposits of gray substance. These fibres are generally believed to be continued by their lower ends into the spinal nerves, though it is also supposed that part of them may terminate below in the gray matter of the cord. Other fibres pass between different parts of the encephalon itself, serving most probably to connect its different masses of gray substance: among the more conspicuous examples of these may be adduced the fibres connecting the cerebrum and cerebellum, forming what are called the superior cerebellar peduncles; fibres passing up from the gray matter in the medulla oblongata and annular protuberance, in company with those from the spinal cord, and having probably a similar connexion superiorly; fibres radiating from the corpus striatum to the cortical gray matter of the cerebrum; fibres extending between adjacent or distant convolutions; and, lastly, the vast body of fibres belonging to the commissures of the cerebrum and middle crura of the cerebellum which pass from one side of the encephalon to the other.

Gray part of the encephalon.—The cortical gray matter which covers the foliated surface of the cerebellum is made up of the following elements, viz.: 1. Pellucid cells of considerable size, [fig. 318, B, *a*.] 2. Cells, for the most part caudate, having the usual granular contents. The cells are imbedded in a finely granular matrix; the greater number of those of the caudate kind have a pyriform shape, and are prolonged at their small end into a simple or branched appendage, as represented in fig. 316, *a*, *c*, and this process, as first remarked by Purkinje, is in most of them directed towards the surface of the cerebellum. 3. Small bodies like cell-nuclei (fig. 317, *c*), densely aggregated without any intervening substance. These lie at some depth from the surface; according to Dr. Todd, they form a thin light-coloured lamina, intermediate between two darker strata of gray matter, which contain the nerve-cells; one of these gray strata being next the white matter of the cerebellum, while the other, which is the deeper coloured of the two, is in contact with the pia mater. 4. Fibres. Tubular nerve-fibres pass from the white into the gray matter, and extend through it nearly as far as the surface. According to Valentin, they form loops and return, but this statement has not been confirmed by other observers.

The gray matter on the convoluted surface of the cerebrum is divided into two, and in some regions into three, strata, by interposed thin layers of white substance. In examining it from without inwards, we meet with, 1, a thin coating of white matter situated on the surface, which on a section appears as a faint white line, bounding the gray substance externally (fig. 319, A, *a*). This superficial white layer is not equally thick over all parts of the cortical substance, but becomes thicker as it approaches the borders of the convoluted surface; it is accordingly less conspicuous on the lateral convex aspect of the

hemispheres, and more so on the convolutions situated in the longitudinal fissure which approach the white surface of the corpus callosum, and on those of the under surface of the brain. It is especially

[Fig. 318.

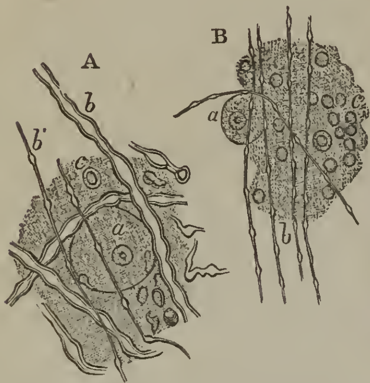
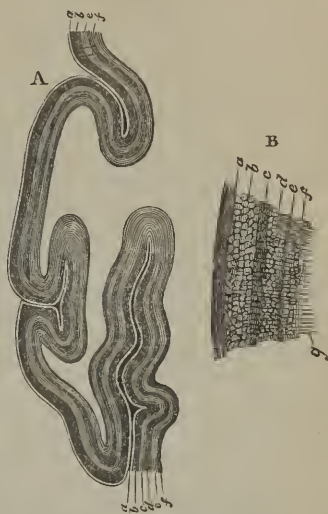


Fig. 319.



[Fig. 318. A. Blending of the vesicular and fibrous nervous matter in the dentate body of the cerebellum:—*a*. Ganglion globule, with its nucleus and nucleolus. *b*. Nerve-tube, slightly varicose, in close contact with the ganglion globule. *b'*. Smaller nerve-tubes. These parts all lie in a finely granular matrix interspersed with nuclei, *c*. B. Vesicular and fibrous matter of the laminæ of the cerebellum. *a*. Ganglion globule. *b*. Very minute nerve-tubes traversing a finely granular matrix, in which are numerous rounded nuclei, *c*.—Todd and Bowman.]

Fig. 319. A. Section of the gray substance of the convolutions of the cerebrum. At the upper part of the figure *a* and *e* are two white, and *b* and *f* two gray strata. At the lower part of the figure an additional white layer (*c*) divides the first gray layer into two, *b* and *d*. (From Remak.)
B. Plan to show the general arrangement of the fibres and cells in the cortical substance. The letters *a*, *b*, *c*, *d*, *e*, *f*, indicate the same strata as in figure A; *g* shows fibres coming from the central white matter of the brain, and intersecting the stratified white fibres of the cortical substance. (Remak.)

well marked on the middle lobe, near the descending cornu of the lateral ventricle, where the convoluted surface is bounded by the posterior pillar of the fornix, and it has been there described under the name of the reticulated white substance. It consists of remarkably fine tubular fibres, for the most part varicose, which run parallel with the surface of the convolutions, but intersect each other in various directions. The termination and connexions of these fibres are unknown. 2*dly*. Immediately beneath the white layer just described, comes a comparatively thick layer of gray, or reddish gray, matter (fig. 319, A, *b*), the colour of which, as indeed of the gray substance generally, is deeper or lighter according as its very numerous vessels contain much or little blood. Then follow, 3*dly*, another thin whitish layer (*e*), and, 4*thly*, a thin gray stratum (*f*); this last lies next to the central white matter of the hemisphere: Remak considers it as similar in nature to the gelatinous substance of the spinal cord. According to this account, the cortical substance consists of two layers of gray substance, and two of white; but in several convolutions, especially those situated near the corpus callosum, a third white stratum may be

seen (indicated by *c* at the lower end of the figure), which divides the most superficial gray one into two (*b* and *d*), thus making six in all, namely, three gray and three white.

The cortical gray substance consists of nerve-cells of rather small size, usually round or oval and seldom caudate, lying in a granular matrix; also of small nucleus-like vesicles, like those seen in the cortical substance of the cerebellum (fig. 317, *c*), and, according to Dr. Todd, here also collected into a special stratum. Tubular fibres exist throughout; one set of them run parallel with the surface, and at certain depths are more densely aggregated, so as to form the before-mentioned white layers (fig. 319, B, *a*, *c*, *e*); but they are not wanting in the intervening gray strata (*b*, *d*, *f*), only they are there wider apart. The manner in which they begin and end is not known; it seems not improbable, however, that they are dependencies of the commissural system of fibres. These stratified fibres, if they might be so called, are intersected by another set of tubular fibres (*g*), which come from the central white mass of the hemispheres, and run perpendicularly through the cortical substance, becoming finer and spreading more out from each other as they approach the surface.

The further disposition of these central or perpendicular fibres is uncertain; Valentin describes them as forming terminal loops or arches, but this is denied by Remak and Hannover. Remak states that they gradually disappear from view at different depths, as they pass through the successive layers, the last of them vanishing in the superficial gray stratum; but he is unable to say positively how they terminate: it sometimes seemed to him as if the last of them, after intersecting the fibres of the deeper white strata, became continuous with those of the outermost layer; but of this he by no means speaks confidently. Hannover maintains that they are connected at their extremities with the nerve-cells in the cortical substance.

As regards the other collections of gray matter in the encephalon, it may be remarked that they consist of nerve-cells and intercellular granular matter, with tubular fibres in greater or less number; the following details respecting them are given chiefly on the authority of Hannover:—

The corpus striatum and optic thalamus contain cells very much like those of the cortical substance. In the corpora quadrigemina there are larger cells, approaching in size to those of the cerebellum, besides very small cells and nucleiform bodies. The dark matter, forming the so-called locus niger of the cerebral peduncles, and that in the floor of the fourth ventricle, contain caudate cells, many of them of the largest size, with long appendages, and deeply coloured with pigment. In the pineal gland the cells are larger than those of the cerebral convolutions, but with comparatively small nuclei, and many of them contain particles of earthy matter; there are but few of the nucleus-like corpuscles. The anterior lobe of the pituitary body contains dark nerve-cells of moderate size, with coarsely granular contents, along with isolated nucleiform bodies. The posterior lobe, on the other hand, consists of very large cells of soft consistence and variable irregular shape, containing comparatively small nuclei without nucleoli. Many of these last-mentioned cells are furnished with appendages, and it is not uncommon to meet with two united together by a sort of commissure.*

* Rathke considers the pituitary body as belonging to the same class of organs as the thyroid gland, suprarenal bodies, the spleen, &c. As far as I can judge from the examinations I have been able to make of it, it differs greatly in structure, at least in its anterior and larger lobe, from any other part of the encephalon. The substance of the anterior lobe has appeared to me to be constituted by a membranous tissue forming little round cavities or loculi, which are packed full of nucleated cells. The loculi are formed of transparent,

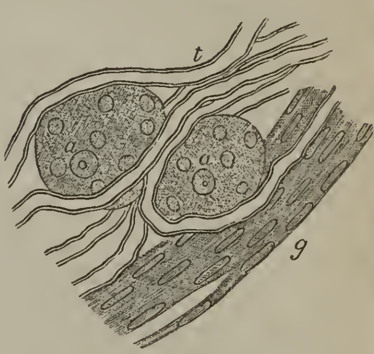
OF THE GANGLIA.

The bodies so named are found in the following situations, viz.: 1. On the posterior root of each of the spinal nerves, on one, and probably the corresponding root of the fifth nerve of the encephalon, and on the seventh pair, glossopharyngeal and pneumogastric nerves, involving a greater or less amount of their fibres. 2. Belonging to the sympathetic nerve. (*a*) In a series along each side of the vertebral column, connected by nervous cords, and constituting what was once considered as the trunk of the sympathetic. (*b*) On branches of the sympathetic; occurring numerously in the abdomen, thorax, neck, and head; generally in the midst of plexuses, or at the point of union of two or more branches. Those which are found in several of the fossæ of the cranium and face are for the most part placed at the junction of fine branches of the sympathetic with branches, usually larger, of the cerebro-spinal nerves; but they are generally reckoned as belonging to the sympathetic system.

The ganglia differ widely from each other in figure and size: those which have been longest known to anatomists are most of them large and conspicuous objects; but, from the researches of Remak, it appears that there are numerous small, or what might be almost termed microscopic ganglia, connected with the nerves of the heart, lungs, and some other viscera.

Ganglions are invested externally with a thin but firm and closely adherent envelope, continuous with the neurilemma or sheath of the nerves, and composed of dense cellular tissue: this outward covering sends processes inwards through the interior mass, dividing it, as it were, into lobules, and supporting the numerous fine vessels which pervade it. A section carried through a ganglion, in the direction of the nervous cords connected with it, discloses to the naked eye merely a collection of reddish-gray matter traversed by the white fibres of the nerves. The nervous cords on entering the ganglion lay aside their membranous sheath, and spread out into smaller bundles, between which the gray ganglionic substance is interposed. The microscope shows that this gray substance consists of nerve-cells and

[Fig. 320.



From the Gasserian ganglion of an adult:—*a. a.* Ganglion globules with their nucleus, nucleated capsule, and pigment. *t.* Tubular fibres, running among the globules in contact with their capsule. *g.* Gelatinous fibres also in contact with the ganglion globules.—Magnified 320 diameters.—Todd and Bowman.]

simple membrane, with a few fibres and corpuscles resembling elongated cell-nuclei disposed round their walls. The cells contained in the cavities were of various sizes and shapes, and not unlike nerve-cells or ganglion globules; they were collected into round clusters, filling the cavities, and were mixed with a semifluid granular substance. This thin granular matter, together with the cells and little specks of a clear glairy substance like mucus, could be squeezed from the cut surface in form of a thick, white, creamlike fluid.

gelatinous fibres. The nerve-cells, or ganglion globules, [fig. 320, *a*,] have mostly a round or oval figure, especially those situated towards the surface of the ganglion; those nearer the centre are often angular or pointed, and some have caudate processes; these last are rare, or, at least, difficult to see, in the ganglia of warm-blooded animals, but they abound in those of cartilaginous fishes. Their cell-wall is said to be stronger than that of the cells found in the brain and spinal cord, and they are moreover inclosed in capsules formed of granular corpuscles and gelatinous fibres, out of which they readily escape when the ganglion is torn up into fragments. The tubular nerve fibres, [fig. 320, *t*,] are, according to Valentin, disposed as follows: one part of them, (fibræ transeuntes,) keeping together in considerable bundles, run straight through the ganglion; the rest (fibræ circumflexæ seu circumnectentes) separate more from each other, and take a circuitous course among the nerve-cells, round which they make various turnings and windings before passing out of the ganglion. The bundles of straight fibres usually keep near the middle of the ganglion and are then surrounded by the globules, but frequently they run on one side. The winding fibres generally run nearer the surface; and when a series of ganglia are connected by a nervous cord, as in the trunk or main part of the sympathetic, it would seem that these winding fibres are destined to pass out in the branches given off from the ganglionic chain, whilst the straight fibres run on unchanged through two or three successive ganglia, until at length they in their turn assume the winding arrangement, approach the surface, and pass off into branches. The gelatinous fibres, [fig. 320, *g*,] leaving the ganglion, pass along the nervous cords with the tubular fibres, and their arrangement will be afterwards further noticed.

Remak and Hannover state that gelatinous fibres arise from the ganglion globules: Valentin, who denies the nervous nature of these fibres, maintains that they are connected only with the inclosing capsules of the ganglion globules, and not immediately with the globules themselves. As regards the connexion of the tubular fibres with the ganglia, there is also a difference of opinion among those observers who have made this difficult point in anatomy a subject of special inquiry. According to Valentin, these tubular fibres are all derived from the brain or spinal cord, and pass through the ganglia, coming, it is true, into close proximity and intimate functional relation with the ganglion globules, but none either originating or terminating in a ganglion. It is contended by others that a part of the fibres in question take their rise in the ganglia, and this opinion is maintained principally on the two following grounds:—1. The observation of Bidder and Volkman, in which Kölliker concurs, that in many cases the communicating nervous cords which conduct tubular fibres from the cerebro-spinal centre to the ganglia contain manifestly fewer of these fibres than are contained in the branches which pass off from the ganglia to be distributed peripherally. 2. The statement of several observers, among others of Hannover and Kölliker, that they have been able actually to trace the continuity of the fibres in question with the caudate processes of the ganglion globules. These observations

would doubtless settle the question, were their correctness established; but it must be admitted that they are not free from fallacy, and still stand in need of confirmation.*

CEREBRO-SPINAL NERVES.

These are formed of the nerve-fibres already described, collected together and bound up in membranous sheaths. A larger or smaller number of fibres enclosed in a tubular sheath form a little round cord, usually named a *funiculus;* if a nerve be very small, it may consist of but one such cord, but in larger nerves several funiculi are united together into one or more larger bundles, which, being wrapped up in a common membranous covering, constitute the nerve, (fig. 321.) Accordingly, in dissecting a nerve, we first come to an outward

Fig. 321.

Represents a nerve consisting of many smaller cords or funiculi wrapped up in a common cellular sheath.—A, the nerve. B. A single funiculus drawn out from the rest. (After Sir C. Bell.)

covering, formed of cellular tissue, but often so strong and dense that it might well be called fibrous. From this common sheath we trace laminæ passing inwards between the larger and smaller bundles of funiculi, and finally between the funiculi themselves, connecting them together as well as conducting and supporting the fine blood-vessels which are distributed to the nerve. But, besides the interposed cellular tissue which connects these smallest cords, each funiculus has a

* Since the above was written, the alleged connexion of tubular fibres with ganglionic cells has been confirmed in a very decided manner by Wagner, who states that he has been able to trace it most unequivocally in the ganglia of the spinal nerves, trigeminus and vagus of the torpedo, skate, and dog-fish, in which, from the small amount of cellular tissue intermixed, the nervous fibres can be followed with comparative ease. He has also succeeded in observing it in the sympathetic ganglia of some of those fishes. He finds that almost invariably two fibres are connected with each ganglion-cell, at opposite sides or opposite poles, as it were, one directed centrally or towards the root of the nerve, and the other outwardly towards its branches, and he thence infers that every fibre which issues from a ganglion-cell corresponds to an entering one with which it is connected through the medium of the cell, and that there is no multiplication of the fibres in a ganglion. The nerve fibre, as it leaves the cell, appears like a mere prolongation from it, containing the same kind of granular matter; but further on it enlarges and acquires the dark double contour, indicating the presence of the white substance. The cell-wall appears to be continuous with the sheath (tubular membrane) of the fibre, which in these fishes is remarkably strong. Some cells, generally smaller than the rest, are unconnected with fibres. (See Rudolph Wagner, über den Bau und Endigung der Nerven. Leipz. 1847; and Ann. des Sc. Nat., March, 1847.)

Robin has also observed, in the spinal ganglia of the skate, ganglion globules each with two tubular nerve-fibres connected at opposite poles. He states also that he saw smaller ganglion globules, similarly connected with smaller or sympathetic nerve-fibres. (Ann. des Sc. Nat., Avril, 1847.)

On repeating Wagner's observation on the spinal ganglia of the common skate along with my friend Professor A. Thomson, of Edinburgh, we very readily found ganglion globules with a tubular fibre proceeding from their opposite poles, as described by Wagner.

distinct and independent tubular sheath of its own, as will be further noticed presently.

The common sheath and its subdivisions consist of cellular tissue, presenting the usual white and yellow constituent fibres of that texture, the latter being present in considerable proportion. The tubular sheaths of the funiculi, on the other hand, appear to be formed essentially of a fine transparent membrane, which may without difficulty be stripped off in form of a tube from the little bundle of nerve fibres of which the funiculus consists. When examined with a high power of the microscope, this membrane presents the aspect of a thin transparent film, which in some parts appears to be quite simple and homogeneous, but is more generally marked with extremely fine reticulated fibres. Corpuscles resembling elongated cell nuclei may also be seen upon it when acetic acid is applied.* The tissue investing a nerve and inclosing its proper fibres, as now described, is named the *neurilemma*, and the term is for the most part applied indiscriminately to the whole of the enveloping structure, though some anatomists use it to denote only the sheaths of the funiculi and smaller fasciculi, whilst they name the general external covering of the nerve its "cellular sheath" (*vagina cellulosa*).

The funiculi of a nerve are not all of one size, but all are sufficiently large to be readily seen with the naked eye, and easily dissected out from each other. In a nerve so dissected into its component funiculi, it is seen that these do not run along the nerve as parallel insulated cords, but join together obliquely at short distances as they proceed in their course, the cords resulting from each union dividing in their further progress to form junctions again with collateral cords; so that in fact the funiculi composing a single nervous trunk have an arrangement with respect to each other similar to that which we shall presently find to hold in a plexus formed by the branches of different nerves. It must be distinctly understood, however, that in these communications the proper nerve-fibres do not join together or coalesce. They pass off from one nervous cord to enter another, with whose fibres they become intermixed, and part of them thus intermixed may again pass off to a third funiculus, or go through a series of funiculi and undergo still further intermixture; but throughout all these successive associations the nerve-fibres remain, as far as known, individually distinct, like interlaced threads in a rope.

The fibres of the cerebro-spinal nerves are chiefly, in some cases perhaps exclusively, of the tubular kind, but in most instances there are also gelatinous fibres in greater or less number. Moreover, it has often appeared to me as if there were filaments of extreme tenuity, like the white filaments of cellular tissue, mixed up with the true nerve-fibres within the sheaths of the funiculi. Lying alongside each other, the fibres of a funiculus form a little skein or bundle, which runs in a waving or serpentine manner within its tubular sheath; and the alter-

* In several observations it has seemed to me that these corpuscles were attached to the inner surface of the membrane. Mr. Beck informs me that he has repeatedly found the membrane appearing as if composed of polygonal scales or tables, and hence he regards it as an epithelium. I have not succeeded in observing an epithelial structure in it.

nate lights and shadows caused by the successive bendings being seen through the sheath, give rise to the appearance of alternate light and dark cross stripes on the funiculi, or even on larger cords consisting of several funiculi. On stretching the nerve, the fibres are straightened and the striped appearance is lost.

Vessels.—The blood-vessels of a nerve supported by the neurilemma divide into very fine capillaries, said by Henlé to measure in the empty state not more than $\frac{1}{6000}$th of an inch in diameter. These, which are numerous, run parallel with the funiculi, but are connected at intervals by short transverse branches, so as in fact to form a network with very long narrow meshes.

Branching and Conjunction of Nerves.—Nerves in their progress very commonly divide into branches, and the branches of different nerves not unfrequently join with each other. As regards the arrangement of the fibres in these cases, it is to be observed, that, in the branching of a nerve, portions of its fibres successively leave the trunk and form branches; and that, when different nerves or their branches intercommunicate, fibres pass from one nerve to become associated with those of the other in their further progress; but in neither case (unless at their peripheral terminations) is there any such thing as a division or splitting of an elementary nerve fibre into two, or an actual junction or coalescence of two such fibres together.

A communication between two nerves is sometimes effected by one or two connecting branches. In such comparatively simple modes of connexion, which are not unusual, both nerves commonly give and receive fibres; so that, after the junction, each contains a mixture of fibres derived from two originally distinct sources. More rarely the fibres pass only from one of the nerves to the other, and the contribution is not reciprocal. In the former case the communicating branch or branches will of course contain fibres of both nerves, in the latter of one only.

In other cases the branches of a nerve, or branches derived from two or from several different nerves, are connected in a more complicated manner, and form what is termed a plexus. In plexuses, of which the one named "brachial" or "axillary," formed by the great nerves of the arm, and the "lumbar" and "sacral," formed by those of the lower limb and pelvis, are appropriate examples, the nerves or their branches join and divide again and again, interchanging and intermixing their fibres so thoroughly, that, by the time a branch leaves the plexus, it may contain fibres from all the nerves entering the plexus. Still, as in the more simple communications already spoken of, the fibres remain individually distinct throughout.

Some farther circumstances remain to be noticed as to the course of the fibres in nerves and nervous plexuses.

Gerber* has described and figured nerve-fibres, which, after running a certain way in a nerve, apparently join in form of loops with neighbouring fibres of the same funiculus, and proceed no further. Such loops might of course be represented as formed by fibres which bend back and return to the nervous centre; and so Gerber considers them. He likens them to the loops said to be formed

* Handbuch der allgemeinen Anatomie, (1840,) § 267.

by the fibres at the extremities or peripheral terminations of nerves in various sentient parts, and regards them accordingly as the terminations of sentient fibres appropriated to the nerve itself—as the *nervi nervorum*, in short, on which depends the sensibility of the nerve to impressions, painful or otherwise, applied to it elsewhere than at its extremities. The whole matter is, however, involved in doubt; for, admitting the existence of the loops referred to, which yet requires confirmation, it is not impossible that they may be produced by fibres which run back only a certain way, and then, entering another funiculus, proceed onwards to the termination of the nerve. Again, it has been supposed, that, in some instances of nervous conjunctions, certain collections of fibres, after passing from one nerve to another, take a retrograde course in that second nerve, and, in place of being distributed peripherally with its branches, turn back to its root and rejoin the cerebro-spinal centre. An apparent example of such nervous arches without peripheral distribution is afforded by the optic nerves, in which various anatomists admit the existence of arched fibres, that seem to pass across the commissure between these nerves from one optic tract to the other, and to return again to the brain. These, however, are perhaps to be compared with the commissural fibres of the brain itself, of which there is a great system connecting the symmetrical halves of that organ. But instances of a similar kind occurring in other nerves have been pointed out by Volkmann;* as in the connexion between the second and third cervical nerves of the cat, also in that of the fourth cranial nerve with the first branch of the fifth in other quadrupeds, and in the communications of the cervical nerves with the spinal accessory and the descendens noni. But certain fibres of the optic nerves take a course deviating still more from that followed generally, for they appear to be continued across the commissure from the eyeball and optic nerve of one side to the opposite nerve and eye, without being connected with the brain at all, and thus forming arches with peripheral terminations, but no central connexion. In looking, however, for an explanation of this arrangement, it must be borne in mind that the retina contains nerve-cells or vesicles, like those of the nervous centres, and perhaps the fibres referred to may be intended merely to bring the vesicular matter of the two sides into relation independently of the brain.

Origins or Roots of the Nerves.—The cerebro-spinal nerves, as already said, are connected by one extremity to the brain or to the spinal cord, and this central extremity of a nerve is, in the language of anatomy, named its origin or root. In some cases the root is single, that is, the funiculi or fibres by which the nerve arises are all attached at one spot or along one line or tract; in other nerves, on the contrary, they form two or more separate collections, which arise apart from each other and are connected with different parts of the nervous centre, and such nerves are accordingly said to have two or more origins or roots. In the latter case, moreover, the different roots of a nerve may differ not only in their anatomical characters and connexions, but also in function, as is well exemplified in the spinal nerves, each of which arises by two roots, an anterior and a posterior—the former containing the motory fibres of the nerve, the latter the sensory.

The fibres of a nerve, or at least a considerable share of them, may be traced to some depth in the substance of the brain or spinal cord, and hence the term "apparent or superficial origin" has been employed to denote the place where the root of a nerve is attached to the surface, in order to distinguish it from the "real or deep origin," which is beneath the surface and concealed from view.

To trace the different nerves back to their real origin, and to de-

* Müller, Archiv. (1840) p. 510.

termine the points where and the modes in which their fibres are connected with the nervous centre, is a matter of great difficulty and uncertainty; and, accordingly, the statements of anatomists respecting the origin of particular nerves are in many cases conflicting and unsatisfactory. Confining ourselves here to what applies to the nerves generally, it may be stated, that their roots, or part of their roots, can usually be followed for some way beneath the surface, in form of white tracts or bands distinguishable from the surrounding substance; and very generally these tracts of origin may be traced towards deposits of gray nervous matter situated in the neighbourhood, such, for instance, as the central gray matter of the spinal cord, the gray nuclei of the pneumogastric and glossopharyngeal nerves, the corpora geniculata, and other larger gray masses connected with the origin of the optic nerve. It would further seem probable that certain fibres of the nerve-roots take their origin in these local deposits of gray matter, whilst others become continuous with the white fibres of the spinal cord or encephalon, which are themselves connected with the larger and more general collections of gray matter situated in the interior or on the surface of the cerebro-spinal axis. As has been already more fully stated, (p. 154,) there is a difference of opinion as to the mode in which the nerve-fibres supposed to arise in the gray matter are connected with its elements; some anatomists describing them as forming loops or arches in the gray matter, passing into it, as it were, and returning, whilst others maintain that the fibres are prolonged from the caudate nerve-cells.

The fibres of origin of a nerve, whether deeply implanted or not, on quitting the surface of the brain or spinal cord to form the apparent origin or free part of the root, are in most cases collected into funiculi, which are each invested with a sheath of neurilemma. This investment is generally regarded as a prolongation of the pia mater, and in fact its continuity with that membrane may be seen very plainly at the roots of several of the nerves, especially those of the cervical and dorsal nerves within the vertebral canal, for in that situation the neurilemma, like the pia mater itself, is much stronger than in the cranium. The funiculi, approaching each other if originally scattered, advance towards the foramen of the skull or spine which gives issue to the nerve, and pass through the dura mater, either in one bundle and by a single aperture, or in two or more fasciculi, for which there are two or more openings in the membrane. The nerve-roots in their course run beneath the arachnoid membrane, and do not perforate it on issuing from the cranio-vertebral cavity; for the loose or visceral layer of the arachnoid is prolonged on the nerve and loosely surrounds it as far as the aperture of egress in the dura mater, where, quitting the nerve, it is reflected upon the inner surface of the latter membrane, and becomes continuous with the parietal or adherent layer of the arachnoid. The nerve, on escaping from the skull or spine, acquires its external, stout, fibro-cellular sheath, which connects all its funiculi into a firm cord, and then, too, the nerve appears much thicker than before its exit. The dura mater accompanies the nerves through the bony foramina, and becomes continuous with their external sheath and

(at the cranial foramina) with the pericranium; but the sheath does not long retain the densely fibrous character of the membrane with which it is thus connected at its commencement.

The arrangement of the membranes on the roots of certain of the cranial nerves requires to be specially noticed.

The numerous fasciculi of the olfactory nerve pass through their foramina almost immediately after springing from the olfactory bulb, and then also receive their neurilemma. The bulb itself, and intra-cranial part of the nerve, which are to be regarded as being really a prolongation or lobe of the brain, are invested externally by the pia mater, but are not fasciculated. The arachnoid membrane passes over the furrow of the brain in which this part of the nerve lies, without affording it a special investment.

The optic nerve becomes subdivided internally into longitudinal fasciculi by neurilemma a little way in front of the commissure: on passing through the optic foramen it receives a sheath of dura mater, which accompanies it as far as the eyeball. The acoustic nerve becomes fasciculated, receives its neurilemma, and acquires a firm structure on entering the meatus auditorius internus in the temporal bone, towards the bottom of which it presents one or more small ganglionic swellings containing the characteristic cells. Up to this point it is destitute of neurilema, and is of soft consistence, whence the name "portio mollis" applied to it.

The larger root of the fifth pair acquires its neurilemma and fasciculated character sooner at its circumference than in the centre, so that, in the round bunch of cords of which it consists, those placed more outwardly are longer than those within, and, when all are pulled away, the non-fascicular part of the nerve remains in form of a small conical eminence of comparatively soft nervous substance.

Most of the nerves have ganglia connected with their roots. Thus, the spinal nerves have each a ganglion on the posterior of the two roots by which they arise; and in like manner several of the cranial, viz., the fifth, seventh, glosso-pharyngeal, and pneumogastric, are furnished at their roots, or at least within a short distance of their origin, with ganglia which involve a greater or less number of their fibres, as described elsewhere in the special anatomy of those nerves.

Termination or peripheral extremity of nerves.—The results of modern microscopic discovery seemed for a time to lead to the conclusion that the fibres of nerves do not, strictly speaking, end in the tissues in which they are distributed, but merely dip into those tissues, as it were, and, after forming slings or loops of greater or less width, return sooner or later to the nervous trunks. The further progress of inquiry, has, however, failed to establish the generality of this conclusion, and has even gone far to disprove the existence of the alleged mode of termination in various cases in which it had previously been held to take place; and indeed it must be admitted that the arrangement of the nervous fibres at their peripheral extremities is still but imperfectly understood, as will appear from the following summary of what is at present known on the subject.

In no case was the termination of nerves by loops more generally acknowledged than in voluntary muscle, and accordingly it is so described in the account already given of the nerves of that tissue in the present work (vol. i. p. 320); but certain observations very recently made known by Wagner* are calculated to throw considerable doubt on the opinions hitherto received, especially when viewed in

* Loc. cit.

connexion with the results of collateral inquiries to be presently referred to, which have been made by several observers, respecting the nerves of various other textures. Wagner states, that, in the muscles of the frog, the tubular nerve-fibres may be observed to be at last divided into fine branches, which appear, (although he is not quite certain on this point,) to perforate the sarcolemma of the muscular fibres, and to divide into still finer filaments, not more than $\frac{1}{10000}$th or $\frac{1}{12000}$th of an inch in size, that run between the muscular fibrillæ, where they elude further scrutiny. The looped mode of termination was described by Valentin as occurring in the nerves of the iris and ciliary ligament.

The mode of ultimate distribution of the nerves in the skin and in analogous parts of mucous membrane endowed with a considerable degree of tactile sensibility, is still a subject of much uncertainty.

In the skin of the frog the nerves break up into branches, which become smaller by repeated division, and are at length reduced to fine bundles of only two or three fibres each. The branches frequently join and separate, and the larger ones are observed very generally to run alongside the blood-vessels: the finest ramifications form at last a close network, in which they mutually give and receive fibres. As regards the further disposition of the ultimate fibres, Valentin, E. Burdach, and others, state that they merely pass from one nervous branch or bundle to another, rarely running singly, and that they do not end in the tissue, but, after coursing a longer or a shorter way through the plexus, of which they, in fact, form the finest divisions, return sooner or later to the larger branches. But, although the arrangement appears to the eye such as described, further inquiries have shown that there is something beyond. Thus, fibres have been seen (by Todd and Bowman) passing from the plexus through the superjacent layers of membrane towards the surface of the skin, and not visibly ending in loops, but becoming at last lost to view. In the eyelid of the frog, also, in which the plexiform arrangement of the fine nervous branches is readily seen, Henlé observed nerve-fibres which ran singly a long way, and then disappeared, there being no evidence that they were continuous with others in the form of loops; some seemed to end abruptly, and this appearance, which Henlé was disposed to consider fallacious, has since been described again by Hannover, who moreover saw other primitive fibres dividing into finer filaments, which were arranged into a plexus, and ultimately eluded the sight.

To these examples must be added the very remarkable observations of Schwann on the terminations of the nerves in the web or fin of the tadpole's tail. In that instance, as well as in the mesentery of amphibia, it appeared to Schwann that the ordinary primitive nerve-fibres, after separating from the fasciculi, divided into other fibres of much smaller size, and that the finer fibres resulting from this division, which were destitute of white substance and wanted the dark outline, here and there presented little enlargements or nodules, from whence, again, delicate fibres spread out in various directions, and connected themselves in form of a network.* Subsequent observations made by myself, on the nerves of the tail of the tadpole, are confirmatory of those of Schwann. The fine fibres, which are derived from the division of the ordinary ones, want the bold, dark outline which usually marks the tubular fibres; they also present here and there along their course elongated corpuscles like cell-nuclei; and, from their similarity in aspect to the gelatinous fibres, it might be supposed that they are really prolonged from gelatinous fibres mixed up with the tubular kind in the nervous branches; there can be no doubt, however, as to their source, for fine tubular fibres may be traced, which change their character as they proceed, lose their dark outline, and pass continuously into these pale nucleiferous fibres; moreover, many of the decidedly tubular fibres in this situation are marked with nucleus-like corpuscles.† The tubular fibres might thus be represented as laying aside their white substance and dark outline before dividing or terminating, like those ending in the Pacinian

* These little radiating knots, which are supposed by Schwann to be the remnants of cells from which the fibres are developed, are not to be confounded with the ramified colourless cells (resembling in figure branched pigment cells) which abound in the tissue in which the nerves are distributed. I have never been able to perceive any connexion between the nerve-fibres and these last-mentioned cells.

† In one instance it seemed to me that a tubular fibre divided into two branches.

bodies, to be presently described; but in the present case (of the growing tail of the tadpole) the pale fibres are in reality to be considered as an earlier condition of tubular fibres in progress of development. Schwann, who adopts this view, states that the pale fibres are the forerunners of tubular fibres, and he conceives that they are converted into the latter by acquiring the white substance (medullary sheath), and with this the dark outline. Still, whether perfect or not, these fine fibres must be capable of receiving and conducting sensorial impressions applied to the decidedly sentient membrane in which they are distributed.

The density and opacity of the cutaneous tissue in man and quadrupeds render the investigation of the ultimate distribution of the cutaneous nerves extremely difficult. Nevertheless, Gerber, by boiling portions of skin, and then steeping them in oil of turpentine, succeeded in making the tissue so transparent, that in thin sections of it he was able, as he believes, to see the terminations of the nerves. He describes the nerves as ending in the less sensible parts of the skin by a plexus, the ultimate branches of which consist of two or more fibres; but, in the more sensitive parts, also by loops of single fibres, often much waved or convoluted, which rise from the plexus and enter the papillæ. Krause also states, that, by treating the human skin with nitric acid, he was able to perceive that the simple fibres into which the nervous branches approaching the surface had divided, passed into the papillæ, forming one or sometimes two or three loops or doublings in each; and that often the same fibre would ascend into and come out of several papillæ in succession. On the other hand, Todd and Bowman, although they saw bunches of loop-like fibres in the papillæ of the tongue, which in many respects resemble the cutaneous papillæ, nevertheless failed to detect any such loops in the papillæ of the skin: they were able to trace solitary nerve-tubules ascending a certain way into the papillæ, and then becoming lost to sight, either by simply ending, or else by losing their white substance, by which only they are distinguishable from the fibres of other tissues in this situation. Further evidence seems therefore desirable, in order to determine the point with certainty.

In dissecting the nerves of the hand and foot, certain small oval bodies, like little seeds, are found attached to their branches as they pass through the subcutaneous fat on their way to the skin; and it has been ascertained that each of these bodies receives a nervous fibre which terminates within it. The objects referred to were more than a century ago described and figured by Vater,* as attached to the digital nerves, but he did not examine into their structure, and his observation seems not to have attracted much notice. Within the last few years their existence has been again pointed out by Cruveilhier and other French anatomists, as well as by Professor Pacini of Pisa, who appears to be the first writer that has given an account of the internal structure of these curious bodies, and clearly demonstrated their essential connexion with the nervous fibres. The researches of Pacini have been followed up by Henlé and Kölliker,† who named the corpuscles after the Italian savant; and to their memoir, as well as to the article "Pacinian Bodies," by Mr. Bowman, in the "Cyclopædia of Anatomy," the reader is referred for details that cannot be conveniently introduced here.

[Fig. 322.

A. Nerve from the finger, natural size; showing the Pacinian corpuscles.
B. Ditto, magnified 2 diameters; showing their different size and shape.—Todd and Bowman.]

The little bodies in question (fig. 322) are, as already said, attached in great numbers to the branches of the nerves of the hand and foot, and here and there one or two are found on other cutaneous nerves. They have been discovered also within the abdomen on the nerves of the solar plexus, and they are nowhere more distinctly seen or more conveniently obtained for examination,

* Abr. Vater, Diss. de Consensu Partium Corp. hum.; Vitemb. 1741, (recus in Halleri Disp. Anat. Select. tom. ii.) Ejusd. Museum Anatomicum; Helmst, 1750.

† Ueber die Pacinischen Körperchen: Zurich, 1844.

than in the mesentery and omentum of the cat, between the layers of which they exist abundantly. They are found in the fœtus, and in individuals of all ages. The figure of these corpuscles is oval, somewhat like that of a grain of wheat,—regularly oval in the cat, but mostly curved or reniform in man, and sometimes a good deal distorted. Their mean size in the adult is from $\frac{1}{15}$th to $\frac{1}{10}$th of an inch long, and from $\frac{1}{26}$th to $\frac{1}{20}$th of an inch broad. They have a whitish, opaline aspect: in the cat's mesentery they are usually more transparent, and then a white line may be distinguished in the centre. A slender stalk or peduncle attaches the corpuscle to the branch of nerve with which it is connected. The peduncle consists of a single tubular nerve-fibre ensheathed in filamentous cellular tissue, with one or more fine blood-vessels; and it joins the corpuscle at or near one end, and conducts the nerve-fibre into it. The little body itself, examined under the microscope, is found to have a beautiful lamellar structure (fig. 323). It

[Fig. 323.

Fig. 324.

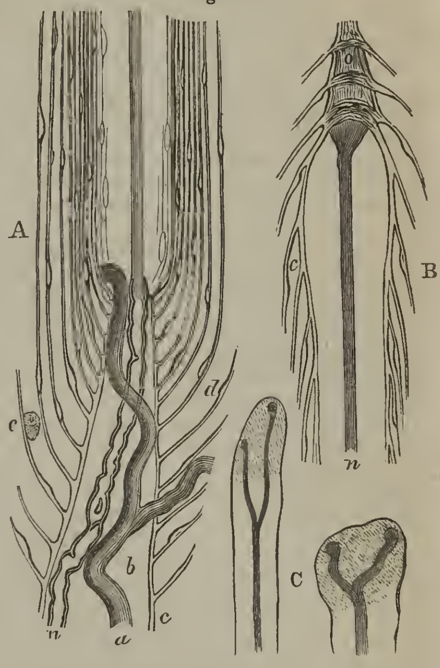


Fig. 323, represents the Pacinian corpuscle, from the mesentery of the cat; intended to show the general construction of these bodies. The stalk and body, the outer and the inner system of capsules, with the central cavity, are seen. *a*. Arterial twig, ending in capillaries, which form loops in some of the intercapsular spaces, and one penetrates to the central capsule. *b*. The fibrous tissue of the stalk prolonged from the neurilemma. *n*. Nerve tube advancing to the central capsule, there losing its white substance, and stretching along the axis to the opposite end, where it is fixed by a tubercular enlargement.

Fig. 324. A. Termination of the stalk, and commencement of the central cavity. *n*. Nerve-tube advancing to the central capsule, and there suddenly losing its white substance and becoming pale. *a*. Artery ending in capillaries; one of which enters an intercapsular space, the other advances with the nerve into the inner capsule. *b*. Conical tube which receives the stalk: the fibrous tissue of the stalk is not represented. *c*. Wall of this tube, continuous with the successive capsules, here seen in sections. *d*. Corpuscle of the capsular wall. *e*. More spherical granular corpuscle, of which a few only exist.

B. Distal end of the central cavity. *n*. Pale nerve advancing along the axis, to be fixed by a swollen part at the further end. *c*. Wall of the central cavity, receiving the insertion of some of the neighbouring capsules, here a little separated from each other by water. *o*. Intercapsular ligament of Pacini, continued a little way towards the surface.

C. Two varieties of bifid extremity of nerve, attached to the distal extremity of the central cavity.—All magnified 320 diameters.—Todd and Bowman.]

consists, in fact, of numerous concentric membranous capsules incasing each other like the coats of an onion, with a small quantity of transparent and probably albuminous fluid lodged between them, the innermost containing a cylindrical cavity filled with the same kind of fluid, into which the nerve-fibre passes. The number of capsules is various; from forty to sixty may be counted in large corpuscles. The series immediately following the central or median cavity, and comprehending about half the entire number, are closer together than the more exterior ones, seeming to form a system by themselves, which gives rise to a white streak often distinguishable by the eye along the middle of the corpuscles. Outside of all, the corpuscle has a coating of ordinary cellular tissue. The capsules, at least the more superficial ones, consist each of an internal layer of longitudinal and an external of circular fibres, which resemble the white fibres of areolar and fibrous tissue, with cell-nuclei attached here and there on the inner layer, and a few branched fibres of the yellow or elastic kind running on the outer. The nerve-fibre, conducted along the centre of the stalk, enters the corpuscle, and passes straight into the central cavity, at the further end of which it terminates.

The fibrous neurilemma surrounding the nerve-fibre in the peduncle accompanies it also in its passage through the series of capsules, gradually decreasing in thickness as it proceeds, and ceasing altogether when the nerve has reached the central cavity. According to Pacini, with whom Reichert agrees in this particular, the neurilemma forms a series of concentric cylindrical layers, which successively become continuous with, or rather expand into the capsules, the innermost, of course, advancing farthest. Others suppose that the capsules are all successively perforated by a conical channel, which gives passage to the nerve with its neurilemma, but at the same time has its own proper wall, round which, on the outside, the capsules are attached. Whichever view may be correct, the capsules are, as it were, strung together where the nerve passes through them, and each intercapsular space, with its contained fluid, is shut off from the neighbouring ones. The nerve-fibre, the disposition of which must now be noticed, is single as it runs along the peduncle, unless where the latter supports two corpuscles; it retains its dark double contour until it reaches the central cavity, where, diminished in size, and freed from its neurilemma, it becomes somewhat flattened, and presents the appearance either of a pale, finely granular, and very faintly outlined band or stripe, little narrower than the previous part of the fibre, or of a darker and more sharply defined narrow line; differing thus in appearance according as its flat side or its edge is turned towards the eye. The pale aspect which the fibre presents in the centre of the corpuscle, has with some probability been ascribed to its losing the white substance or medullary sheath on entering the cavity; Henlé and Kölliker, however, think that it is more likely the result merely of a diminution in size together with a certain degree of flattening. It sometimes happens that the fibre regains its original magnitude and double contour for a short space, and changes again before it terminates; this is especially liable to occur while it passes through a sharp flexure in a crooked central cavity. The fibre ends by a sort of knob at the further extremity of the median cavity, which is often itself somewhat dilated. In many cases, the fibre, before terminating, divides into two branches, as represented in figure c: a division into three has been observed, but this is very rare. In case of division of the fibre, the cavity is generally, but not invariably, divided in a corresponding measure, and the inner set of capsules present a figure in keeping with it. It is worthy of remark, that the nerve-fibre in its course along the cavity runs almost exactly in the axis, and it maintains this position even when passing through the abrupt flexures of an irregularly shaped cavity. It sometimes happens that a fibre passes quite through one corpuscle and terminates in a second, resuming its original size and dark outline while passing from the one to the other. Pappenheim states that he has seen a nerve-fibre going through two Pacinian bodies without terminating in either, but returning again to the parent nerve in the form of a loop. Other varieties occur, for an account of which the reader is referred to the several authorities already mentioned. A little artery enters the Pacinian bodies along with the nerve, and soon divides into capillary branches, which pierce the parietes of the passage and run up between the capsules. Mr. Bowman finds that they then form loops,

and return by a similar route into a vein corresponding to the artery: he states also that a single capillary usually accompanies the nerve as far as the central capsule, and passes some way on its wall, sometimes in a spiral direction.

Nothing positive is known concerning the purpose in the animal economy which these curious appendages of the nerves are destined to fulfil. After passing in review various conjectures which naturally suggest themselves, Pacini, and, after him, Henlé and Kölliker, looking to a certain correspondence in structure between these little bodies and the electric organs of the torpedo and other similarly endowed fishes, are disposed to think that the most promising hypothesis that can in the mean time be adopted is that they are analogous in function with these electric organs. It must be confessed, however, that any experiments that have been instituted for the purpose have as yet altogether failed to elicit proof that the Pacinian bodies develope electricity. Cruveilhier and others suppose that they are morbid or accidental productions, probably resulting from pressure applied to the nerves; but their constant presence (at least in certain regions in the body) in perfectly healthy individuals, at all periods of life, and even in the fœtus, and, above all, their regular and elaborate internal structure, forbid us to regard them as the result of accident or disease.

The fine branches of nerves which enter the cavities of the teeth form plexuses in the vascular pulp, and Valentin describes the fibres as at last ending by loops; according to Purkinje they end in form of pencils at the summit of the pulp.

It has already been incidentally mentioned, that looped nerve-fibres have been seen in the papillæ of the tongue. On the mucous membrane of the nose the branches of the olfactory nerves have a plexiform arrangement, but the manner in which their fibres terminate has not been satisfactorily determined.

The fibres of the optic nerve, on entering the eyeball, spread out in the retina. They become attenuated, and, according to Todd and Bowman, lose their white substance and double contour, and collectively assume a gray aspect. The most recent inquirers, such as Hannover, describe them as neither dividing, nor joining, nor forming loops; these fibres eventually become lost to view, and it has not yet been ascertained how they end. The fine lamina of the retina formed by the fibres is covered both externally and internally with a layer of cells, which are most probably of the same nature as the cells or ganglion globules found in the nervous centres. For further details, the reader is referred to the special description of the eye.

The terminal fibres of the auditory nerve seem to be differently arranged in the different parts of the complex apparatus in which it is distributed. On the membranous ampullæ of the semicircular canals they form loops; but free ends may also be seen among the loops, according to the testimony of more than one observer. In the vestibular sac and common sinus, part of the fibres proceed to the pulverulent calcareous matter contained in those sacculi, and terminate amongst it in a mode not yet precisely ascertained; other fibres spread out on the wall of the sacs, apparently losing their white substance, and becoming connected with a layer of dark nucleated cells. Various observers profess to have seen looped nerve-fibres on the lamina spiralis of the cochlea. Some have observed free ends as well as loops; others, again, could not discover terminal loops. Todd and Bowman describe the fibres as being collected into small, tapering, terminal fasciculi, in which it is very difficult to distinguish the disposition of the individual tubules. The fibres are here mixed with nuclei, but retain their white substance.

As connected with the present subject, I cannot avoid adverting to the remarkable fact discovered by Savi, respecting the terminal fibres of the nerves distributed on the horizontal membranous partitions or diaphragms in the electric apparatus of the torpedo, namely, that these fibres or elementary tubules actually bifurcate or divide dichotomously into branches possessing the same tubular character which inosculate together so as to form a network. Wagner, who has since examined this structure, recognises the division of the tubular fibres, but denies the netlike conjunctions; he states that the nervous tubules divide at first not dichotomously, but into several branches which divaricate from the same point, and then, after repeatedly bifurcating, become greatly reduced in size, lose their dark outline and double contour, and at length can be no longer distin-

guished from the tissue in which they lie. Robin* states that he has observed the division as well as the reticular inosculations of the terminal nerve-tubules in an organ which has been lately discovered in the tail of various common species of rays, and which, in respect of intimate structure at least, offers considerable resemblance to the electric apparatus of the torpedo. I have myself seen the division of the tubular nerve-fibres (though I cannot say how they terminate) in the above-mentioned organ, which, it may be well to add, was discovered by Dr. Stark, of Edinburgh, in 1844, and regarded by him as an electric apparatus.†

From the foregoing account of the peripheral extremities of the nerves, it will be apparent, first, that the disposition of their elementary fibres in terminal loops or in terminal plexuses, through which they return again towards the parent trunks, is by no means general; that, as far as known, they more commonly end by simply truncated or slightly swollen extremities, as in the instance of those entering the Pacinian bodies, or become gradually lost to the sight in the surrounding tissue, usually after considerable reduction in size, and after laying aside their dark outline, probably from privation of their white substance. That, even where apparently terminal loops are observed, it is difficult to say whether these may not, in some cases, be caused by serpentine windings of the fibres previous to their actual termination, which may itself be hidden from view. Secondly, that elementary nerve-fibres, although, as far as is known, they keep entire and distinct in their course along the nerves, do in various instances actually divide into branches, and in some cases unite or inosculate with each other, in approaching their termination. Thirdly, that in certain cases the fibres of nerves come into near relation at their peripheral extremities with cells resembling the nerve-cells of the brain and ganglia.‡

Differences of cerebro-spinal nerves.—It remains to notice the differences which have been observed among the cerebro-spinal nerves in regard to the size of their fibres, and the proportionate amount of the different kinds of fibres which they respectively contain.

As already stated, both tubular and gelatinous fibres exist in cerebro-spinal nerves, and those of the tubular kind differ greatly from each other in size; but some anatomists consider that two different average sizes prevail among the tubular fibres, scarcely, if at all, connected by intermediate gradations; they accordingly distinguish two varieties of them, characterized by their size; and Volkmann and Bidder, as will be more fully explained in treating of the sympathetic nerve, are further of opinion that the small kind are a system of nervous fibres derived from the ganglia. Be this as it may, the authors just named have bestowed much pains in endeavouring to arrive at an approximate estimate of the relative amount of the large and the small fibres in different nerves, and the following are the more important results of their researches:—

1. The nerves of voluntary muscles have very few small fibres, usually in not larger proportion than about one to ten.

2. In the nerves of involuntary muscles, whether derived immediately from the cerebro-spinal system or from the sympathetic, the small fibres eminently preponderate, being about a hundred to one.

* Annales des Sc. Nat., Mai, 1847.

† Magazine of Natural History, vol. xv. p. 121.

‡ It may not be out of place here to remark, that M. Quatrefages describes the cutaneous nerves of the singularly organized fish named the Amphioxus or Branchiostoma, as finally dividing into excessively delicate homogeneous fibres, each of which terminates singly in a little oval body below the fine integument. In the figure which accompanies his description, the small terminal bodies referred to appear not unlike oval cells.

3. The nerves going to the integuments have always many small fibres, at least as many small as large.

4. Nerves of sentient parts of mucous membranes have from five to twenty times more small fibres than large: in mucous membranes possessing little sensibility the nerves are made up chiefly of small fibres. The nerves distributed in the pulp of the teeth consist principally of large fibres.

It is plain, however, that Volkmann and Bidder must have reckoned in with their small fibres more or fewer of the gelatinous sort, so that the proportion assigned to the small fibres in their estimate must be taken as including gelatinous as well as tubular fibres; and this agrees with the observation previously made by Remak, that many more gelatinous fibres are contained in the cutaneous than in the muscular nerves. The roots of the spinal nerves contain fine fibres, but according to Remak only in very small proportion: Volkmann and Bidder state that in man the anterior roots contain proportionally more large fibres than the posterior. In almost all nerves the fibres diminish in size as they approach their termination.

The fibres of the optic nerve for the most part resemble the white fibres of the brain, and readily become varicose. The same is true of the acoustic nerve, from its origin to its entrance into the internal auditory foramen, where it becomes fasciculated; also of the intracranial part of the olfactory, which, however, contains in addition gray matter and nerve-cells. The branches of the olfactory in the nose are almost wholly made up of fibres bearing nuclei, and having all the outward characters of the gelatinous fibres, like which, also, they cohere or cling fast together in the bundles which they form. Some branches seem to consist entirely of such fibres; others contain a few tubular fibres intermixed, which, however, may perhaps be derived from the nasal branches of the fifth pair. This peculiarity of the branches of the olfactory nerve, distinguishing it so much from other cerebral nerves, was, as far as I know, first distinctly pointed out by Todd and Bowman, although it seems not altogether to have escaped the notice of preceding anatomists, of Valentin, for instance, who compares the branches of the olfactory to the nervi molles of the sympathetic.

OF THE SYMPATHETIC OR GANGLIONIC NERVE.

This name is commonly applied to a nerve or system of nerves present on both sides of the body, and consisting of the following parts, viz.:—1. A series of ganglia placed along the spinal column by the side of the vertebræ, connected with each other by an intermediate nerve-cord, and extending upwards to the base of the skull and downwards as far as the coccyx. This principal chain of ganglia, with the cord connecting them, forms what is often named the trunk of the sympathetic. 2. Communicating branches, which connect these ganglia or the intermediate cord with all the spinal and several of the cranial nerves. 3. Primary branches passing off from the ganglionic chain or trunk of the nerve, and either bestowing themselves at once, and generally in form of plexuses, on the neighbouring blood-vessels, glands, and other organs, or, as is the case with the greater number, proceeding in the first instance to other ganglia of greater or less size (sometimes named prævertebral), situated in the thorax, abdomen, and pelvis, and usually collected into groups or coalescing into larger ganglionic masses near the roots of the great arteries of the viscera. 4. Numerous plexuses of nerves, sent off from these visceral or prævertebral ganglia to the viscera, usually creeping along the branches of arteries, and containing in various parts little ganglia disseminated among them. Some of these plexuses also receive contributions from spinal or cerebral nerves, by means of branches which immediately

proceed to them without previously joining the main series of ganglia.

Structure of the sympathetic nerve.—The nervous cords of the sympathetic consist of tubular fibres, and of gelatinous fibres mixed with a greater or less amount of filamentous cellular tissue, and enclosed in a common external fibro-cellular sheath. The tubular fibres differ greatly from each other in thickness. A few are of large size, ranging from $\frac{1}{2000}$th to $\frac{1}{1500}$th of an inch; but the greater number are of much smaller dimensions, measuring from about $\frac{1}{8300}$th to $\frac{1}{4500}$th of an inch in diameter, and, though having a well-defined sharp outline, for the most part fail to present the distinct double contour seen in the larger and more typical examples of the tubular fibre. The gelatinous fibres present the characters already described as pertaining to them.

The more gray-looking branches or bundles of the sympathetic consist of a large number of the gelatinous fibres mixed with a few of the tubular kind; the whiter cords, on the other hand, contain a proportionally large amount of tubular fibres, and fewer of the gelatinous; and some parts of the nerve, gray fasciculi, and white fasciculi, respectively constituted as above described, run alongside of each other in the same cords for a considerable space without mixing. This arrangement may be seen in some of the branches of communication with the spinal nerves, in the trunk or cord which connects together the principal chain of ganglia, and in the primary branches proceeding from thence to the viscera. In the last-mentioned case the different fasciculi get more mixed as they advance, but generally it is only after the white fasciculi have passed through one or more ganglia that they become thoroughly blended with the gray; and then, too, the nervous cords receive a large accession of gelatinous fibres, (apparently derived from the ganglia,) which are mixed up with the rest, and take off more and more from their whiteness.

Regarding the nature of the gelatinous fibres, there is, as has already been remarked, a wide difference of opinion, for several anatomists of reputation deny that they are nervous fibres at all: it becomes necessary, therefore, before proceeding further, to consider briefly this question.

Those who deny the nervous nature of these fibres, rely chiefly on the difference in aspect and anatomical characters between them and undoubted nervous fibres, and account for their presence in the nerves by referring them to the class of enveloping structures; maintaining, in short, that they are nothing but fibres of cellular tissue imperfectly developed or otherwise modified, and that they serve merely as a sort of neurilemma for the tubular or true nervous fibres. To this it may be replied, in the first place, that the large proportionate amount of gelatinous fibres in many branches of the sympathetic nerve, and their varying arrangement in respect of the tubular fibres associated with them, do not accord with the idea of an enveloping tissue. Next, as regards discrepancy in structure and outward aspect, we may call to mind the instance of the striped and plain muscular fibres, as satisfactorily proving that textures differing widely in anatomical characters may yet fundamentally agree in function and vital endowments. Moreover, it is not correct to say that the gelatinous fibres have the characters of cellular tissue either perfectly or imperfectly formed; it would be much nearer the truth to compare their appearance, as some have done, to that of the tubular nervous fibres in an early stage of the development, although in saying this it is not meant that they are actually unfinished nervous fibres. If there be transitions, as is said, between the gelatinous fibres and the filaments of cellular tissue, transitions, too, it may be replied, are not wanting between them

and the tubular nerve-fibres. Thus, Purkinje has described small-sized pale fibres bearing nuclei, and thus in so far agreeing with gelatinous fibres, which were, nevertheless, filled with oleaginous fluid contents like the tubular; and so slight, indeed, would seem to be the gradations with which the two kinds of fibres pass into each other, that Volkmann and Bidder, both excellent observers, have been taxed with unwittingly reckoning gelatinous fibres among those which they consider as the true nervous fibres, while professing to distinguish between them. Again, an undoubted nervous tubule may in some part of its course assume characters approaching closely to those of the fibres in dispute. Thus, it is no uncommon thing for a tubular fibre of the most typical form, in approaching its termination, to decrease in size, lose its double contour, and present the faint outline and finely granular aspect of a gelatinous fibre: we have seen that this change always occurs when a fibre enters a Pacinian body; and in the tadpole's tail, as already described, nervous tubules are continued into fibres which are marked with nuclei, and wholly agree in appearance with the gelatinous fibres; these are probably immature, it is true, but yet they are distributed to a sentient part, and are capable of conducting sensorial impressions. It would seem as if the difference in more obvious characters between the different parts of the fibres in these cases, and perhaps also that between nerve-fibres in general, depended mainly on their respective size, and on the different proportion of their white substance, as well as on the presence or absence of nucleiform corpuscles. Were further proof wanting that a pale faintly granular aspect, want of dark outline, cohesion with its neighbours, and abundant nuclei along its course, ought not to be considered as depriving a fibre of its nervous character, we need only refer to the structure of the nasal part of the olfactory nerve, already pointed out.

But it is further objected, that, whilst tubular fibres have been seen to arise from ganglionic cells, those of the gelatinous sort are unconnected with these bodies, and appear to proceed from their inclosing capsules,—a difference both distinguishing them from nervous fibres, and indicative of their enveloping or neurilemmatic character. Without, however, admitting or denying the force of this objection, were it founded in fact, it must be remembered that it rests principally on negative evidence directly opposed by the positive observations of Remak and Hannover; and the strenuous denial by Valentin and other highly respectable authorities, of the connexion even of the tubular fibres with ganglionic cells,—a connexion which has been so decidedly established by subsequent observations,—ought to render us distrustful of an objection resting on negative evidence in a case so nearly analogous.

In the last place, it is asserted that the gelatinous fibres do not continue in the nerves as far as their extremities, and that they are accordingly wanting in the branches of nerves distributed in the coats of the intestines, and in various other parts supplied by the sympathetic. But this statement is inconsistent with the observations both of Remak* and of Beck;† and the latter observer maintains even that very fine bundles of the sympathetic sometimes consist solely of gelatinous fibres.

We have next shortly to consider the relation between the sympathetic and the cerebro-spinal system of nerves. On this important question two very different opinions have long existed, in one modification or another among anatomists. 1. According to one, which is of old date, but which has lately been revived and ably advocated by Valentin, the sympathetic nerve is a mere dependency, offset, or embranchment of the cerebro-spinal system of nerves, containing no fibres but such as centre in the brain and cord, although it is held that these fibres are modified in their motor and sensory properties in passing through the ganglia in their way to and from the viscera and involuntary organs. 2. According to the other view, the sympathetic nerve (commonly so called) not only contains fibres derived from the brain

* De Syst. Nerv. Struct., p. 25. † Phil. Trans., 1846, p. 216.

and cord, but also proper or intrinsic fibres which take their rise in the ganglia; and in its communications with the spinal and cranial nerves, not only receives from these nerves cerebro-spinal fibres, but imparts to them a share of its own proper ganglionic fibres, to be incorporated in their branches and distributed peripherally with them. Therefore, according to this latter view, the sympathetic nerve, commonly so called, though not a mere offset of the cerebro-spinal nerves, yet, receiving as it does a share of their fibres, is not wholly independent; and, for a like reason, the cerebro-spinal nerves (as commonly understood) cannot be considered as constituted independently of the sympathetic; in short, both the cerebro-spinal and the sympathetic are mixed nerves, that is, the branches of either system consist of two sets of fibres of different and independent origin, one connected centrally with the brain and cord, the other with the ganglia. Hence, if we look to the central connexion of their fibres as the essential ground of distinction among nerves, the cerebro-spinal system of nerves might, strictly speaking, be considered as consisting of and comprehending all the fibres having their centre in the cerebro-spinal axis, whether these fibres run in the nerves usually denominated cerebral and spinal, or are distributed to the viscera in the branches of the nerve usually named the sympathetic; and, on the same ground, the sympathetic or ganglionic system, strictly and properly so called, would consist of and comprehend all the fibres connected centrally with the ganglia, wherever such fibres exist and into whatever combinations they enter, whether proceeding to the viscera or distributed peripherally with the nerves of the body generally; the ganglia on the roots of the spinal and cerebral nerves, with the nerve-fibres emanating from them, being reckoned into this system, as well as those usually denominated sympathetic. While ready, however, to acquiesce in the justice of the above distinction, we do not mean to employ the terms already in use in a sense different from that which is currently received.

In endeavouring to decide between the two views above stated, it may be first observed that the existence in the sympathetic nerve of fibres connected centrally with the cerebro-spinal axis is proved not only by tracing bundles of fibres from the roots of the spinal nerves along the communicating branches and into the sympathetic, but by the pain or uneasy sensations which arise from disease or disturbance of organs, such as the intestines, supplied exclusively by what are considered branches of the sympathetic, and by experiments on living or recently killed animals, in which artificial irritation of the roots of the spinal nerves, or of various parts of the cerebro-spinal centre, caused movements of the viscera.

This fact, it is evident, accords with both of the above-mentioned opinions respecting the constitution of the sympathetic; but it may be further shown that this nerve contains fibres which arise from the ganglia and take a peripheral course, so that the second of the two opinions approaches nearer to the truth. In support of this assertion we may adduce the actual observation of nerve-fibres proceeding from the nerve-cells of the ganglia,—a fact which may now be considered as established, and which would of itself be sufficient to settle the question, unless we suppose, with Wagner, that each of these ganglionic fibres has its root in the cerebro-spinal centre, and is merely connected with, or, as it were, interrupted by, a ganglionic globule in its course; in which case, however, such fibres would still be peculiar and different from those fibres which are unconnected with ganglia. But there are independent grounds for believing that more

fibres pass out of the sympathetic ganglia than can possibly be derived from the brain and cord. This seems to follow from a comparison of the aggregate size of the branches issuing from these ganglia with that of all the branches which can be supposed to enter them. To explain this, however, we must first consider the mode of communication between the sympathetic and spinal nerves.

The branches of communication which pass between the ganglia or gangliated cord of the sympathetic and the spinal nerves, are connected with the anterior and greater branch of each of the latter nerves, a little in advance of the spinal ganglion; and at the point of connexion the communicating branch in most cases divides into two portions, one, central, running towards the roots of the spinal nerve and the spinal cord, the other, peripheral, taking an outward course along with the anterior branch of the spinal nerve, with which it becomes incorporated and distributed. It can scarcely be doubted that the central portion, whilst it may contain fibres sent by the sympathetic to the spinal nerves or to the spinal cord, must necessarily contain all those which proceed from the cord to the sympathetic, and that, on the other hand, the peripheral division must consist of fibres immediately proceeding from the sympathetic and distributed peripherally with the spinal nerve. It is further observed, that, in some of the junctions with the spinal nerves, the central and peripheral divisions of the communicating branch are about equal in size, and that in others the central part is greater than the peripheral, whilst in others, again, the peripheral prevails over the central. Now, in an animal such as the frog, in which the spinal nerves are of small size and few in number, it is possible, with the aid of the microscope, to compare by measurement the central and peripheral divisions of the communicating branch in all the communications between the sympathetic and the spinal nerves, or even to count the fibres when the branches are very fine; and by such a comparison Volkmann and Bidder have shown, that, after making all reasonable deductions and allowances, the whole amount of the fibres, or at least the aggregate bulk of the fasciculi, which obviously pass from the sympathetic and run outwards with the spinal nerves, considerably exceeds that of the central fasciculi which must contain the fibres contributed to the sympathetic from the cerebro-spinal system; and if to these peripheral fibres we add the branches distributed to the viscera, it seems plain that more fibres must proceed from the ganglia than can possibly be supposed to enter them from the spinal nerves or spinal cord, and that consequently the ganglia must themselves be centres in which nerve-fibres take their rise. It is worthy of remark, that, in the frog, according to the observations of the anatomists just named, the central division of the communicating cord greatly exceeds the peripheral in the connexions with the upper spinal nerves, but that lower down it gradually diminishes, absolutely as well as in comparison with the peripheral, and at length disappears altogether, so that the fasciculi connected with the 8th and 9th spinal nerves are entirely peripheral in their course.

Another circumstance still remains to be noticed respecting the communications of the sympathetic and spinal nerves. It has been long known that in most of these communications there are usually two connecting cords passing between the sympathetic and the spinal nerve; and it has been remarked also by various observers, that these cords contain gray as well as white fasciculi. More recently, however, Todd and Bowman have called attention to the fact that one of the two connecting cords is altogether of the gray kind, consisting of gelatinous fibres, with, as usual, a very few white or tubular fibres mixed with them; and this observation has since been confirmed by Beck. The other cord either is entirely white, or, more commonly, is made up of a white and a gray portion running alongside each other. It seems highly probable that the white cords and the white fasciculi of the mixed cords contain the cerebro-spinal fibres which the spinal nerves contribute to the sympathetic, and that the gray cords and fasciculi are contributions from the sympathetic to the spinal nerves. In corroboration of this view, Mr. Beck observes that the gray cords on leaving the ganglia give small branches to the neighbouring vessels, and are reduced in size before joining the spinal nerves. Another interesting fact respecting these communications has been pointed out by the last-named observer, somewhat similar to that previously noticed in the frog, namely, that, whilst the gray and white connecting cords are in the thorax of nearly equal size, the gray one relatively increases lower down,

and in the pelvis constitutes the sole communication between the sacral ganglia of the sympathetic and the spinal nerves, the white branches from the latter to the sympathetic passing over the sacral ganglia without joining them, to enter the sympathetic plexuses sent to the pelvic viscera.

The tubular fibres of each white communicating fasciculus can be traced back to both the anterior and the posterior root of the spinal nerve, and gelatinous fibres from the gray fasciculus may be traced up into the anterior root, and as far as the ganglion of the posterior root, which root has also gelatinous fibres above the ganglion. Whether these central gelatinous fibres proceed from the sympathetic to the spinal cord (possibly to be distributed to its vessels), or are sent from the cord and spinal ganglia to the sympathetic, or pass both ways, is as yet uncertain.

As to the further progress of the cerebro-spinal fibres conveyed to the sympathetic by the communicating branches, Valentin has endeavoured to show, that, after joining the main gangliated cord or trunk of the sympathetic, they all take a downward direction, and, after running through two or more of the ganglia, pass off in the branches of distribution, leaving the trunk considerably lower down than the point where they joined it. He conceives that this arrangement, which he calls "lex progressûs," is proved by experiments on animals, in which he found, that, on irritating different parts of the cerebro-spinal axis, as well as different branches of nerves, the visceral movements which followed bore a relation to the point irritated, which corresponded with the notion of such an arrangement. Volkmann and Bidder, on the other hand, endeavour to show that this opinion cannot be reconciled with the observed anatomical disposition of the fibres; nor will the experimental evidence in its favour apply to the upper part of the sympathetic, where, as Valentin himself admits, motorial fibres must be supposed to run in an upward direction, to account for the contraction of the pupil which follows irritation of the cervical part of the sympathetic, unless, indeed, we suppose that the movement in this case is reflex.

From what has been stated, it seems reasonable to conclude that nerve-fibres take their rise in the ganglia both of the cerebro-spinal and sympathetic nerves, and are in both kinds of nerves mixed with fibres of cerebral or spinal origin; that the ganglia are nervous centres which probably receive through afferent fibres impressions of which we are unconscious and reflect these impressional stimuli upon efferent or motor fibres; that perhaps, even, certain motorial stimuli emanate from them, the movements excited by or through the ganglia being always involuntary, and affecting chiefly the muscular parts of the viscera, the sanguiferous, and perhaps the absorbent vessels; and that, in fine, the chief purpose served in the animal economy by the ganglia and the ganglionic nerve-fibres, whether existing in acknowledged branches of the sympathetic, or contained in other nerves, is to govern the involuntary, and, for the most part, imperceptible movements of nutrition, in so far at least as these movements are not dependent on the brain and spinal cord.

Among various physiologists of consideration, who adopt this view in a more or less modified shape, some are further of opinion that the fibres of ganglionic origin differ in structure, size, and other physical characters, from those which arise in the cerebro-spinal axis. Thus, Remak considers the ganglionic fibres to be exclusively of the kind above described under the name of gelatinous fibres, and these he accordingly proposed to distinguish by the name of "organic," from the tubular, which he regarded as cerebro-spinal fibres. Volkmann and Bidder, on the other hand, rejecting the organic fibres of Remak, denying to them indeed the character of nervous elements altogether,

endeavour to show that the true ganglionic fibres are identical with the smaller variety of tubular fibres, which especially abound in the branches of the sympathetic—fibres which they hold are characterized by small size and by other peculiarities already mentioned. They contend, that, wherever these smaller fibres occur, whether in the sympathetic or in the branches or the roots of the spinal or cerebral nerves, they are derived from the ganglia, whilst the larger-sized tubular fibres, in the sympathetic as well as in the spinal nerves, are of cerebro-spinal origin. As regards this question, I must confess, that, although there is sufficient ground to admit the existence of fibres centering in the ganglia, as well as of others which arise from the cerebro-spinal axis, there does not seem to me to be conclusive evidence in favour of the opinions either of Remak or of Volkmann and Bidder, as to peculiar anatomical characters being distinctive of the fibres of different origin; and, for aught that has been proved to the contrary, all three varieties of fibres spoken of, large tubular, small tubular, and gelatinous, may arise both in the cerebro-spinal axis and in the ganglia; although it is certainly true, that the two latter kinds largely predominate in the sympathetic, and abound in other nerves, or branches of nerves, which appear to receive large contributions from ganglia.

VITAL PROPERTIES OF THE NERVOUS SYSTEM.

The fibres of nerves are endowed with the property of transmitting impressions, or the effect of impressions, from the point stimulated towards their central or their peripheral extremities. One class of fibres conduct towards the nervous centres, and are named "afferent," their impressions being "centripetal;" another class of fibres conduct towards their distal extremities, which are distributed in moving parts, and these fibres are named "efferent," whilst their impressions are "centrifugal." Impressions propagated centrally along the nerves to the brain give rise to sensations, varying according to the nerve impressed, and the objective cause of the impression: stimuli transmitted outwardly, on the other hand, are conveyed to muscles, and excite movements. Motorial stimuli thus passing along efferent nervous fibres may emanate from the brain, as in voluntary and emotional movements, or possibly from some other central part, as in the case of certain involuntary motions; or such stimuli may be applied in the first instance to afferent fibres, by these conducted to the brain or some other central organ, and then "reflected" by the central organ to efferent fibres, along which they are propagated to the muscle or muscles to be moved; and in this case the intervention of the central organ may give rise to sensation or not, the difference in this respect probably depending on the part of the nervous centre where the reflexion takes place.

The property of conducting a stimulus or propagating its effects in a determinate direction, belongs to the fibres of the nerves, and in all probability also to the fibrous part of the nervous centre, while it is probable that to the gray matter of the central organs, and especially to its cells or vesicles, is assigned the office of receiving impressions

conveyed from without, and presenting them to the conscious mind,—of mediating between the mind and the efferent fibres in excitation of the latter by mental stimuli (as in voluntary and emotional acts), of transferring to efferent fibres stimuli conducted to the centre by afferent fibres in the production of reflex movements, and, possibly, of originating purely corporeal stimuli in certain involuntary motions. Many physiologists suppose, that, in addition to these endowments, the nerves have a peculiar power of controlling and regulating the molecular changes and chemical actions which occur in nutrition and in other allied processes; but it may be fairly questioned, whether the effect justly attributable to the nerves in such cases, is not produced merely through the influence which they exert over the motions of the minute vessels and contractile tissues concerned in the processes referred to.

The properties above mentioned, of the nerves and nervous centres, have been commonly ascribed to a peculiar force developed in the nervous system, which has received the names of "nervous force," "nervous principle," "nervous influence," and "vis nervosa" (in the largest sense of that term); and whilst some physiologists consider that force as a species of agency altogether peculiar to living bodies, others have striven to identify it with some of the forces known to be in operation in inanimate nature. Not a few of the latter have regarded the nervous agency as identical with electricity in some of its modifications, whilst others, acknowledging truly that electricity is a powerful stimulant of the nerves, and, as such, eminently calculated to set in play the nervous force, and admitting that the two have some characters in common, nevertheless maintain that there is quite sufficient difference in their modes of manifestation to mark them as distinct.

The greater number of nerves possess both afferent and efferent fibres, and are named compound or moto-sensory, inasmuch as they minister both to sensation and motion. In such compound nerves the two kinds of fibres are mixed together and bound up in the same sheaths; but in the most numerous and best-known examples of this class, the afferent and efferent fibres, though mixed in the trunk and branches of the nerves, are separated at their roots. This is the case in the spinal nerves: these have two roots, an anterior and posterior, both for the most part consisting of many funiculi, and the posterior passing through a ganglion with which the fibres of the anterior root have no connexion. Now it has been ascertained by appropriate experiments on animals, that the anterior root is efferent and contains the motor fibres, and that the posterior is afferent and contains the sensory fibres. The fifth pair of cranial nerves has a sensory root furnished with a ganglion, and a motor root, like the spinal nerves. The glosso-pharyngeal and pneumogastric nerves are also decidedly compound in nature; they are also provided with ganglia at their roots, which involve a greater or less number of their fasciculi; but it has not yet been satisfactorily determined whether in these nerves the fibres which have different properties are collected at the roots into separate bundles, nor how they are respectively related to the ganglia.

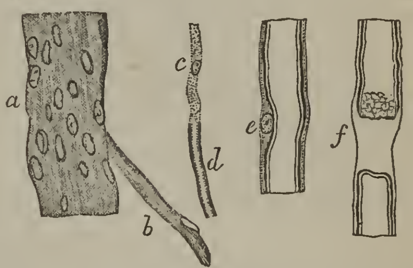
The sympathetic, as already stated, contains both afferent and efferent fibres.

Simple nerves are such as contain either afferent or efferent fibres only. The olfactory, auditory, and optic are simple afferent and sensory nerves. The third, fourth, and sixth, the facial, the spinal accessory and hypoglossal nerves, are generally regarded as examples of simple motor nerves; there is reason to believe, at least, that they are simple and motor in their origin, or as far as their proper fibres are concerned, and that the sensibility evinced by some of them in their branches is owing to sensory fibres derived from other nerves which join them in their progress.

DEVELOPMENT OF NERVES.

Schwann found that, in the fœtal pig, three inches long, the commencing nerves consisted of a granular matter indistinctly arranged in pale, longitudinal, coherent fibres, with cell-nuclei contained in or attached to them. Though he has not been able to trace their earliest stages, he infers, from the analogy of the muscular tissue, that these fibres are formed by the coalescence of cells whose nuclei remain, and accordingly supposes that they are tubes filled with finely granular matter (fig. 325). In a somewhat more advanced stage these pale fibres lose their granular aspect, and acquire the dark contour,—in short, put on the characters of ordinary tubular fibres; and many of them may be seen which have undergone this alteration in a part of their length, whilst the remaining part is still in its primitive condition, (fig. 325, *c*, *d*). The pale fibre is supposed to acquire dark contours in consequence of the formation of the "white substance" or "medullary sheath;" but the mode in which this substance is added to the pale fibre is uncertain. Schwann is inclined to think that it is formed as a secondary deposit on the internal surface of the tubular membrane, which he supposes to exist in the pale fibre as a tube formed by the coalesced walls of the primary cells, and that the granular matter contained in the pale fibre remains and forms the "primitive band" or "axis." Most of the nuclei disappear, but here and there one may be seen on a tubular nerve-fibre, situated, according to Schwann, within the tubular membrane, between it and the white substance, as represented in fig. 325, *e*. When first formed, the fibres are of comparatively small size.

Fig. 325.



Various stages of the development of nerve;—*a*. Earliest stage. *b*. Detached fibre. *c*. Nucleated fibre in the lower part of which, *d*, the white substance of Schwann has begun to be deposited. *e*. Nucleus in a more fully-formed fibre between the white substance and tubular membrane. *f*. Displays the tubular membrane, the contained matter having given way.—(After Schwann.)

In growing parts of the embryo which extend themselves outwards, the more distant portion of the nerves, like that of other continuous structures, must be the last formed; and in the tadpole's tail Schwann observed that the fibres of the more remote and growing nervous branches are smaller and devoid of the dark contour, but are a continuation of fibres (of earlier and older branches) which possess that character; so that the deposition of white substance seems to advance along the fibres in a peripheral direction, the part which is nearer the centre and begins earlier to be formed being also first perfected. As mentioned in a former page (169), little angular knots are observed in the tadpole's tail, where several of these pale fibres meet together; and these Schwann supposes to be remnants of formative cells which had branched out and united with neighbouring cells to form the reticular nerve-fibres. Kölliker, who has lately investigated the development of the tissues in batrachian larvæ, is also of opinion that the nervous

fibres are formed by the junction of ramified cells; he, however, further concludes from his observations, that the pale fibres which first appear enlarge, that fine tubular fibres are then developed in their substance, either singly or in slender fasciculi of two or three, and that the latter fibres at first end abruptly, but eventually form loops.

As to the formation of the nerve-cells found in the gray matter of the brain, spinal cord, and ganglia, but very little is known. Valentin conceives that they are formed round other cells which serve them as nuclei, their granular contents being first deposited, and afterwards their inclosing cell-wall. Others suppose that they are developed from nuclei like ordinary cells, and then acquire their peculiar contents. The nucleus-like bodies and the pellucid cells of different sizes found in the cortical gray matter of the brain, have been supposed to be successive conditions of the larger granular cells in progress of development; and some physiologists think it not improbable that a constant succession of these cells is produced to take the place of others that are destroyed and consumed after fulfilling their office.

The divided ends of a nerve that has been cut across readily reunite, and in process of time true nerve-fibres are formed in the cicatrix, and restore the continuity of the nervous structure. The conducting property of the nerve, as regards both motion and sensation, is eventually re-established through the reunited part.

NERVOUS SYSTEM.

CEREBRO-SPINAL AXIS.

The *nervous system* consists of two parts—a central part, which includes the brain and spinal cord, and is named the cerebro-spinal axis, and a peripheral part, which comprises all the nerves in the body. The anatomy of the nerves, which again are subdivided into a cerebro-spinal and a sympathetic system, will be subsequently treated of, whilst the present section will be devoted to a description of the central portion of the nervous system.

The *cerebro-spinal axis* is contained partly within the cavity of the cranium, and partly within the vertebral canal; it is symmetrical in its form and structure throughout, consisting of a right and a left half, which correspond in every particular, and are joined together along the middle line by fibres of nervous substance, which pass across the longitudinal fissures existing between them. These connecting fibres form the commissures of the brain and spinal cord.

Enclosed within the skull and the vertebral canal, the cerebro-spinal axis is protected by the bony walls of those two cavities; but it is also surrounded by three membranes, which afford it additional protection and support, and are subservient to its nutrition. These envelopes, which will be described hereafter, are, a dense fibrous membrane named the dura mater, a serous membrane called the arachnoid, and a highly vascular membrane named the pia mater.

The cerebro-spinal axis is divided by anatomists into the encephalon (ἐν, κεφαλή, the head), the enlarged upper part contained within the cranium, and the *spinal cord*, contained within the spinal canal. The encephalon is again divided into the *cerebrum*, or *brain proper;* the *cerebellum*, little brain, or *after-brain;* the *tuber annulare*, or pons Varolii, and the *medulla oblongata*. It should be remarked, that the term *brain*, in a general sense, is commonly applied to the entire encephalon, but that it also has a limited application to the cerebrum only.

WEIGHT OF THE ENCEPHALON.

The chief sources of information on this subject are the tables published by Dr. Sims,* Dr. Clendinning,† Tiedemann,‡ and Dr. John Reid.§ The following table is deduced from their observations. The weights given by Tiedemann have been converted into ounces avoirdupois, the weight employed by the three British ob-

* Sims; Medico-Chirurg. Trans., vol. xix., pp. 353–7.

† Clendinning; Medico-Chirurg. Trans., vol. xxi., pp. 59–68.

‡ Tiedemann; Das Hirn des Negers, Heidelberg, 1837, pp. 6, 7.

§ Reid; London and Edinburgh Monthly Journal of Medical Science, April, 1843, p. 298, &c.

servers. All instances of fractional parts of ounces are classed with the next highest integral number, so that the term 50 oz., for example, includes all cases of brains weighing more than 49 oz., but not exceeding 50. From the tables of Dr. Sims and Dr. Clendinning those cases have been rejected in which cerebral disease is said to have existed.

TABLE I.

Males, aged 21 years and upwards.

Weight in oz. avoirdupois.	Number of brains at each weight observed by: Clendinning.	Sims.	Tiedemann.	Reid.	Total number at each weight.	Classification into three groups to show the *prevailing weight*,	
34	—	—	—	1	1	62 cases. from 34oz. to 45oz.	Difference 11.
37	—	2	—	—	2		
38	1	—	—	—	1		
39	—	3	—	1	4		
40	—	2	—	1	3		
41	—	3	—	2	5		
42	2	4	2	—	8		
43	—	6	2	3	11		
44	1	6	2	3	12		
45	6	8	—	1	15		
46	2	10	—	8	20	170 cases. from 46oz. to 53oz.	Difference 7.
47	2	6	—	10	18		
48	4	8	2	11	25		
49	3	2	2	12	19		
50	4	4	5	13	26		
51	3	3	2	19	27		
52	—	5	4	6	15		
53	4	2	4	10	20		
54	3	2	1	5	11	46 cases. from 54oz. to 65oz.	Difference 11.
55	—	—	2	4	6		
56	—	—	1	6	7		
57	—	—	—	2	2		
58	—	1	4	2	7		
59	—	1	2	3	6		
60	—	—	—	1	1		
61	—	—	2	1	3		
62	—	—	1	—	1		
63	—	—	—	1	1		
65	—	—	1	—	1		
Tot.	35 +	78 +	39 +	126 =	278		

Females, aged 21 years and upwards.

Weight in oz. avoirdupois.	Number of brains at each weight observed by: Clendinning.	Sims.	Tiedemann.	Reid.	Total number at each weight.	Classification into three groups, to show the *prevailing weight.*	
31	—	—	—	1	1	32 cases. from 31oz. to 40oz.	Difference 9.
32	—	1	—	—	1		
35	—	2	—	—	2		
36	—	4	—	—	4		
37	—	3	1	2	6		
38	2	—	—	—	2		
39	—	3	1	2	6		
40	3	3	—	4	10		
41	2	8	—	2	12	125 cases. from 41oz. to 47oz.	Difference 6.
42	3	6	1	3	13		
43	6	6	—	7	19		
44	5	4	—	13	22		
45	4	9	—	7	20		
46	2	9	2	12	25		
47	2	5	—	7	14		
48	—	2	2	2	6	34 cases. from 48oz. to 56oz.	Difference 8.
49	—	1	2	7	10		
50	—	2	1	4	7		
51	—	—	2	4	6		
52	1	—	—	—	1		
53	—	1	—	—	1		
54	—	2	—	—	2		
56	—	1	—	—	1		
Tot.	30 +	72 +	12 +	77 =	191		

According to this table, the maximum weight of the adult male brain, in a series of 278 cases, was 65 oz., and the minimum weight 34 oz. In a series of 191 cases, the maximum weight in the adult female was 56 oz., and the minimum 31 oz.; the difference between the extreme weights in the male subject being no less than 31 oz., and in the female 25 oz. The weight of the adult male brain appears, therefore, to be subject to a wider range of variety than that of the female. By grouping the cases together in the manner indicated by brackets, it is found that in a very large proportion, the weight of the male brain ranges between 46 oz. and 53 oz., and that of the female brain between 41 oz. and 47 oz. The *prevailing* weights of the adult male and female brain may therefore be said to range between those terms; and by taking the mean, an *average* weight is deduced of 49½ oz. for the male, and of 44 oz. for the female brain,—results which correspond closely with the statements generally received.

Although many female brains exceed in weight particular male brains, the general fact is sufficiently shown, that the adult male encephalon is heavier than that of the female,—the average difference being from 5 to 6 oz. This general

superiority in absolute weight of the male over the female brain, is shown by Table II. to exist at every period of life. In new-born infants the brain was found by Tiedemann to weigh 14¼ oz. to 15¾ oz. in the male, and 10 oz. to 13¼ oz. in the female.*

Anatomists have differed considerably in their statements as to the period at which the brain attains its full size, and also as to the effect of old age in diminishing the weight of this organ. Sœmmerring concluded that the brain reached its full size as early as the third year; the Wenzels and Sir W. Hamilton fixed the period about the seventh, and Tiedemann between the seventh and eighth. Gall and Spurzheim were of opinion that the brain continued to grow until the fortieth year. The tables of Dr. Sims show a gradual increase in the weight of the brain up to the twentieth year, and a further irregular increase, until the maximum is reached between forty and fifty years, after which there is a decrease. From the following Table (II.), founded on the observations of Sims, Tiedemann, and Reid, it appears that in general the weight of the brain increases rapidly up to the seventh year, then more slowly to between sixteen and twenty, and again more slowly to between thirty-one and forty, at which time it reaches its maximum point. Beyond that period, there appears a slow but progressive diminution in weight of about 1 oz. during each subsequent decennial period; thus confirming the opinion, that the brain diminishes in advanced life. It will also be seen from the table that the general results are the same in both sexes.

All other circumstances being alike, the size of the brain appears to bear a general relation to the mental power of the individual,—although instances occur in which this rule is not applicable. The brain of Cuvier weighed upwards of 64 oz.,† and that of the late Dr. Abercrombie about 63 oz. avoirdupois.‡ On the other hand, the brain in idiots is remarkably small. In three idiots, whose ages were sixteen, forty, and fifty years, Tiedemann found the weight of their respective brains to be 19¾ oz., 25¾ oz., and 22½ oz; and Dr. Sims records the case of a female idiot twelve years old, whose brain weighed 27 oz.

The weight of the human brain being taken at about 3 lbs. (48 oz.), it is found to be absolutely heavier than the brain of all the lower animals except the elephant and whale. In the elephant, the brain, according to Perrault, Moulins, and Sir A. Cooper, weighs between 8 and 10 lbs.; whilst that of the whale was found by Rudolphi, in a specimen 75 feet long, to weigh upwards of 5 lbs.§

The *relative weight of the encephalon to the body* is liable to great variation; nevertheless, the facts to be gathered from the tables of Clendinning, Tiedemann, and Reid, furnish this interesting general result:—In a series of 81 males, the average proportion between the weight of the brain and that of the body, at the ages of twenty years and upwards, was found to be as 1 to 36·5; and in a series of 82 females, to be as 1 to 36·46. In these cases, the deaths were the result of more or less prolonged disease; but in 6 previously healthy males, who died suddenly from disease or accident, the average proportion was 1 to 40·8.

The proportionate weight of the brain and body is greater at birth than at any other period of life, being, according to Tiedemann, about 1 to 5·85 in the male, and about 1 to 6·5 in the female. From the tables already referred to, it further appears that the proportion diminishes gradually up to the tenth year, being then about 1 to 14. From the tenth to the twentieth year, the relative increase of the body is most striking, the ratio of the two being at the end of that period about 1 to 30. After the twentieth year, the general average of 1 to 36·5 prevails, with a further trifling decrease in advanced life.

* This fact is not without interest in practical midwifery, for it has been shown that by far the larger number of difficult labours occur in the birth of male children. Professor Simpson—London and Edinburgh Monthly Journal of Medical Science, 1845.

† Emille Rousseau—Maladie et autopsie de M. G. Cuvier. Lancette Française. Mai 26, 1832. The precise weight given by M. Rousseau is 3 livres, 11 ounces, 4½ gros (old French weight). This being reduced to kilogrammes and thence converted into oz. avoirdupois, gives 64 oz. and nearly one-third.

‡ Cormack's Journal, December, 1844. Dupuytren's brain is stated by Tiedemann (op. cit. p. 9,) to have weighed 58 oz. apothecary's wt. = 63½ oz. avoirdupois. But in the Report of the Autopsy published in the Lancette Française, Feb. 1835, the weight is given as 2 livres 14 ounces (old French wt.) = only to 50 oz. Avoirdupois.

§ In Tiedemann, op. cit. p. 15.

TABLE II.

Weight in oz.	Birth.	1 year.	1 to 4.		4 to 7.		7 to 10		10 to 15		16—20.		21—30.		31—40.		41—50.		51—60.		61—70.		71—80.		81 to 90.		Weight in oz.
10	1'	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
12	1'	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12
14	2 1'	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14
16	1	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16
18	..	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18
20	..	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20
22	..	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	22
24	..	1 1'	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	24
26	..	..	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26
28	..	1'	—	1'	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	28
30	..	..	1	1'	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	30
32	..	1 1'	—	2'	—	1'	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1'	—	1'	32
34	..	..	—	3'	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	34
36	..	..	3	2'	—	2'	—	—	—	—	—	—	—	2'	—	2'	—	1'	—	—	—	1'	—	1'	—	—	36
38	..	..	—	6'	—	2'	—	1'	—	—	—	—	—	1'	—	1'	—	2'	3	2'	1	1'	—	1'	—	—	38
40	..	1	1	2'	1	2'	—	—	—	1'	—	1'	1	6'	—	1'	—	3'	5	4'	3	1'	—	1'	—	—	40
42	..	..	2	3'	3	2'	2	1'	—	1'	—	2'	2	5'	3	3'	1	8'	2	4'	3	2'	1	4'	3	1'	42
44	..	..	—	—	2	2'	2	1'	1	4'	—	4'	3	12'	2	12'	5	6'	5	7'	4	3'	4	2'	—	—	44
46	..	..	1	1'	1	—	—	4'	3	2'	—	5'	2	6'	5	11'	8	7'	10	6'	8	7'	3	3'	—	—	46
48	..	..	—	1'	1	—	1	—	—	—	1	3'	7	7'	9	2'	13	8'	3	4'	9	—	4	—	1	—	48
50	..	..	—	—	1	—	1	—	3	—	—	2'	7	5'	12	5'	16	3'	6	1'	4	—	1	1'	2	—	50
52	..	..	—	—	—	—	2	—	1	—	1	—	8	—	7	2'	15	—	7	—	2	—	—	—	—	—	52
54	..	..	—	—	1	—	—	—	—	—	3	1'	1	—	8	1'	7	1'	3	—	—	—	2	—	—	—	54
56	..	..	—	—	—	—	1	—	1	—	2	—	2	—	3	—	1	—	5	—	—	1'	—	—	—	—	56
58	..	..	—	—	—	—	—	—	—	—	—	—	1	—	5	—	1	—	2	—	1	—	1	—	—	—	58
60	..	..	—	—	—	—	—	—	1	—	—	—	—	—	2	—	2	—	—	—	2	—	—	—	—	—	60
62	..	..	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	62
64	..	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	64
66	..	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	66
	3-3'	4-3'	9-22'		10-11'		9-7'		10-8'		7-18'		34 — 44'		58 — 40'		71 — 39'		51 — 28'		37 — 16'		16 — 14'		6 — 2'		

* This Table contains the weight of 580 brains of both sexes, 325 male and 255 female, arranged according to age. The horizontal lines mark the weight in oz. (avoirdupois), each line or interspace indicating a difference of two ounces. The vertical columns show the ages from birth up to 90 years, the width of each column being proportionate to the period which it includes. The figures in these columns show the number of brains at each weight.

The curved lines, drawn, as nearly as may be, through the average weight in each column, present to the eye the different variations in weight through the whole period.

The accented figures and the dark line refer to the female brains. The dotted line drawn between two of the columns of male brains is intended to show that the extreme deviation of the thin line at that place is regarded as an irregularity, depending probably on the small number of male brains collected at that age.

Viewed in relation to the weight of his body, the brain of man may be stated generally to be heavier than the brains of the lower animals; but there are some exceptions to the rule, as in the case of certain species of small birds, in the smaller apes, in monkeys, and in some small rodent animals.

In some of the examples in the following table,* the brain is heavier, and in others lighter relatively to the body than it is in man.

Blue-headed Tit	1 to 12	Porpoise . .	1 to 93
Canary . .	1 to 14	Rabbit . .	1 to 140
Goldfinch .	1 to 24	Cat . . .	1 to 156
Linnet . .	1 to 24	Dog . .	1 to 305
Monkey (small)	1 to 22	Horse . .	1 to 400
Field-mouse .	1 to 31	Elephant .	1 to 500
Gibbon . .	1 to 48	Sheep . .	1 to 350
Rat . .	1 to 76	Ox . .	1 to 860†

M. Leuret‡ has found, from extensive observation, that the proportionate weight of the brain to the body, in the four classes of vertebrate animals, may be represented by the following numbers:

In Fishes, as	1 to 5668	In Birds,	1 to 212
Reptiles,	1 to 1321	Mammalia,	1 to 186

WEIGHTS OF THE SEVERAL PARTS OF THE ENCEPHALON.

As the result of observations made in reference to this subject, on the brains of 53 males and 34 females, between the ages of twenty-five and fifty-five, Dr. J. Reid has given the following table:—

	Males:		Females.		Difference.	
	oz.	drs.	oz.	drs.	oz.	drs.
Average weight of cerebrum	43	15¾	38	12	5	3¾
" cerebellum	5	4	4	12¼	0	7¾
" pons and medulla oblongata		15¾	1	0¼	0	½
" entire encephalon	50	3½	44	8½	5	11

From this it appears that the proportionate weight of the cerebellum to that of the cerebrum, is, in the male, as 1 to 8$\frac{4}{7}$, and in the female as 1 to 8¼.

In the new-born infant the ratio is strikingly different to what it is in the adult, being, according to Chaussier, from 1 to 13 to 1 to 26; by Cruveilhier it was found to be 1 to 20.

In most mammalia, the cerebellum is found to be heavier in proportion to the cerebrum, than it is in the human subject; in other words, the cerebrum is larger in proportion to the cerebellum in man.

Sœmmerring§ pointed out the fact that the brain is larger in proportion to the nerves connected with it in man than in the lower animals. With the view of showing the size of the brain in proportion to the rest of the nervous system in different cases, a comparison has been made of the width of the cerebrum with that of the medulla oblongata. From this it appears, that the proportionate diameter of the brain to that of the medulla oblongata is greater in man than in any animal, except the dolphin, in which creature it must be remembered that the cerebral lobes exhibit a disproportionate lateral development. The width of the cerebrum in man, as compared with that of the medulla oblongata at its base or broadest part, is about 7 to 1.

* Selected from Cuvier's Leçons, &c., 2d edition, par F. G. Cuvier & Laurillard. 1845. Paris.

† We are indebted to Professor Owen for the following information concerning the relative weight of the brain and body in the Chimpanzce (Simia Troglodytes).

Weight of brain, in a half-grown male . . 9¾ oz.
Weight of body, in a nearly adult female, 61 lbs. = 976 oz.
Proportion between the two weights 1 to 100.

‡ Anat. Comp. du Syst. Nerv., &c. Paris, 1839. Tom. i., p. 423.

§ De basi encephali, Gœttingæ. 1778.

In the ourang it is	6 to 1
In certain monkeys .	5 and 4 to 1
In the dog	11 to 6
In the cat	11 to 4
In the rabbit	8 to 3
In the ox	13 to 5
In the horse . . .	21 to 8
In the falcon . . .	34 to 13
In the sparrow . . .	18 to 7
In the dolphin . . .	13 to 1*

WEIGHT OF THE SPINAL CORD.

Divested of its membranes and nerves, the spinal cord in the human subject weighs from 1 oz. to $1\frac{3}{4}$ oz., and therefore its proportion to the encephalon is about 1 to 33. Meckel gives it as 1 to 40.

The disproportion between the brain and the spinal cord becomes less and less in descending the scale of the vertebrata, until at length, in the cold-blooded animals, the spinal cord becomes heavier than the brain. Thus, in the mouse, the weight of the brain, in proportion to that of the spinal cord, is as 4 to 1; in the pigeon, as $3\frac{1}{3}$ to 1; in the newt, only as $\frac{5}{9}$ to 1; and in the lamprey, as $\frac{1}{75}$ to 1.

In comparison with the size of the body, the spinal cord in man may be stated in general terms to be much smaller than it is in animals. In regard to the cold-blooded animals, to birds, and to small mammalia, this has been actually demonstrated, but not in reference to the larger mammalia.

THE SPINAL CORD.

The *spinal cord*, or *spinal marrow* (medulla spinalis), is that part of the cerebro-spinal axis which is situated within the vertebral canal. It extends from the margin of the foramen magnum of the occipital bone, to about the lower part of the body of the first lumbar vertebra. It forms the continuation of the medulla oblongata above, and ends below in a slender filament, which is prolonged to the termination of the sacral canal.

The spinal cord does not occupy, either by its length or thickness, the entire space within that canal. On the contrary, invested closely by a proper membrane (the pia mater), the cord is enclosed within a sheath, both longer and larger than itself, which is formed by the dura mater, and which is itself separated from the walls of the canal by numerous vascular plexuses, and much loose cellular tissue. The interval between the investing membrane and the sheath of the cord, is lined by a serous membrane (the arachnoid), and is filled by a fluid called the cerebro-spinal fluid. Within this space the cord is suspended or supported by proper ligaments, which serve to fix it at different points to its sheath. The anterior and posterior roots of the several pairs of spinal nerves pass across the space from the surface of the cord, towards the corresponding intervertebral foramina. Since the cord terminates at the upper part of the lumbar region, it occupies only the two upper thirds of the spinal canal, and the elongated roots of the lumbar and sacral nerves, which descend nearly vertically from the cord to reach the lumbar intervertebral and the sacral foramina, form a lash of nervous cords named the *cauda equina*, which occupies the remaining and lower third of the spinal canal.

* Cuvier's Leçons; ut suprà.

Although the cord usually ends near the lower border of the body of the first lumbar vertebra, it sometimes terminates a little above or below that point, as opposite to the last dorsal or to the second lumbar vertebra. The position of the lower end of the cord also varies according to the state of curvature of the vertebral column, in the flexion forwards of which, as in the stooping posture, the end of the cord is slightly raised.—In the fœtus, at an early period, the length of the cord corresponds with that of the vertebral canal; but after the third month, the canal and the roots of the lumbar and sacral nerves begin to grow more rapidly in proportion, so that at birth the lower end of the cord reaches only to the third lumbar vertebra.

The length of the spinal cord is from fifteen to eighteen inches; and it varies in diameter in different situations. Its general form is cylindrical, but it is somewhat flattened before and behind. It is not of uniform size or shape throughout, but presents two enlargements—an upper, or cervical, and a lower, or lumbar. The cervical enlargement is of greater size and extent than the lower. It reaches from the third cervical to the first dorsal vertebra; its greatest diameter is from side to side. The lower or lumbar enlargement is situated about opposite the last dorsal vertebra; its greatest diameter is from before backwards, and by Foville* it is said to be chiefly due to an increase in bulk of the anterior region of the cord.—Below this enlargement, the cord tapers into a conical point. Sometimes it forms one or two bulbs or swellings towards its lower end. The cervical and lumbar enlargements have an evident relation to the size of the nerves which supply the upper and lower limbs, and which are connected with those regions of the cord,—in accordance with the general fact observed in the animal kingdom, that near the origin of large nerves, the nervous substance is accumulated in larger proportion. On its commencement in the embryo, the spinal cord is destitute of these enlargements, which, in their first appearance and subsequent progress, correspond with the growth of the limbs.

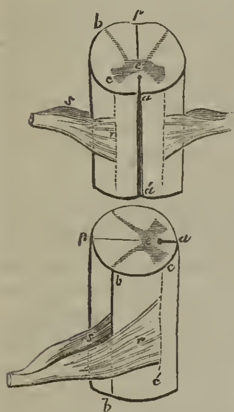
The long free and slender filament in which the cord terminates, descends in the middle line amongst the nerves composing the cauda equina, and, becoming blended with the lower end of the sheath opposite to the first or second sacral vertebra, passes on to be fixed to the lower end of the sacral canal, or to the base of the coccyx. It is named the *central ligament* of the spinal cord; it is of a fibrous structure, and contains no nervous substance, except for a short distance at its upper end; it is, therefore, not a nerve, although it was at one time so considered, and was named *nervus impar*. It appears to be a prolongation of the pia mater or innermost membrane, which, being attached at its lower end to the dura mater and vertebral canal keeps pace with the latter in its growth, whilst the cord relatively shortens. It consists of fibrous tissue with a few fine elastic filaments intermixed; and it must assist in supporting the cord, and in maintaining its position during the movements of the trunk. A small vein has been sometimes seen upon it.

* Traité compl. de l'Anat., &c. du Syst. Nerv. Cerebro-Spinal. Paris, 1844. Part I., p. 138.

When removed from the vertebral canal, and divested of its membranes, the spinal cord is seen to be marked by longitudinal *fissures.* Of these, two run along the middle line, one in front and the other behind, and are named the *anterior* and *posterior median fissures,* fig. 326, *a* and *p.* By means of these, which penetrate only a certain distance into its substance, the cord is divided into two lateral and symmetrical halves, which, however, are connected in their whole length by a cross portion of nervous substance called the *commissure.*

The *anterior median fissure, a a,* is more distinct than the posterior, and penetrates about one-third of the thickness of the cord, but its depth increases towards the lower end. It contains a fold or lamelliform process of the pia mater, and also many blood-vessels, which are thus conducted to the centre of the cord. At the bottom of this fissure is seen the connecting portion of white substance named the *anterior white commissure.*

Fig. 326.



Plans in outline, showing the front A, and the sides, B, of the spinal cord with the fissures upon it; also sections of the gray and white matter, and the roots of the spinal nerves. *a, a.* Anterior. *p, p.* Posterior fissure. *b.* Posterior, and *c,* Anterior horn of gray matter. *e.* Gray commissure. *a e c,* Anterior white column. *c e b,* Lateral columns. *a e b,* antero-lateral column. *b e p,* Posterior columns. *r,* Anterior, and *s,* Posterior roots of a spinal nerve.

The *posterior median fissure, p p,* is less marked in the greater part of its extent than the anterior, but becomes more evident towards the upper part of the cord. Numerous blood-vessels, accompanied by slender filamentous processes derived from the inner membrane, pass into this fissure. Lastly, the bottom of the fissure is separated from the central gray matter of the cord only by a very thin layer of white substance, which has been named the posterior white commissure; but some maintain that the fissure actually reaches the gray matter.

Besides these two *median* fissures, two *lateral* furrows or fissures have been described on each side of the cord, corresponding with the lines of attachment of the spinal nerves. The anterior and posterior roots of these nerves, as will be hereafter specially described, are attached to the cord in four rows, of which two are seen in front, fig. 326, *r,* at a little distance on either side of the anterior median fissure, and two behind, *s,* near the posterior median fissure. Now, along the line of attachment of the posterior roots, there is in each half of the cord a fissure leading down to the gray matter, which there comes to the surface. This is the *posterior lateral fissure, b,* by which the corresponding half of the cord is divided into an anterior and a posterior column.

By some anatomists, an *anterior lateral fissure* has been described as existing along the line of attachment of the anterior roots, B, *c c'* ; but, in reality, there is no fissure to be seen on the surface at this part, although the white substance of the cord is divided by a prolongation of the gray matter, A, *c,* from within, which, however, does not reach the surface. Thus, each lateral half of the cord is divided by the pos-

terior lateral fissure into a *posterior*, *p e b*, and an *antero-lateral* column, *a e b*; and although we cannot trace an anterior lateral fissure, this antero-lateral portion of the cord may, for the convenience of description, be considered as subdivided into an *anterior* and a *lateral column* by the internal gray matter.

On the posterior surface of the cord (throughout *its whole length*, according to Foville, but much more evidently in the upper part,) there are two slightly-marked longitudinal furrows situated one on each side, close to the posterior median fissure, and marking off, at least in the cervical region, a slender tract, named the *posterior median* column. Between the roots of the spinal nerves, on each side, the cord is convex, and sometimes has a longitudinal mark upon it, corresponding with the line of attachment of the ligamentum denticulatum.

Foville* states that in a new-born child, there is a narrow accessory bundle of white matter, running along the surface of the lateral column, separated from it by a streak of grayish substance. According to the same authority, this narrow tract enlarges above, and may be traced upwards along the side of the medulla oblongata into the cerebellum.

Structure of the spinal cord.—The spinal cord consists of white and gray nervous substance. The white matter is situated externally, whilst the gray matter is disposed in the interior, in a peculiar manner, to be now described. On a transverse section, figs. 326, 327, it presents two crescent-shaped masses of similar form, placed one in each lateral half of the cord with their convexities towards one another, and joined across the middle by a transverse portion of gray matter. Each of these gray crescents has an anterior and a posterior cornu or horn. Of these, the posterior is long and narrow, and reaches the surface at the posterior lateral fissure. The anterior horn is shorter and thicker than the posterior; it extends towards the line of attachment of the anterior roots of the nerves, but it does not reach the surface of the cord. The transverse median portion of *gray* matter which connects the two crescents is named the *gray commissure* of the cord, *e*. In front of it, there is a tolerably thick layer of white substance, separating it from the bottom of the anterior median fissure, *a*; this is named the *anterior white commissure*. In like manner there is another white layer behind the gray matter, named the *posterior white commissure*, but this is very

[Fig. 327.

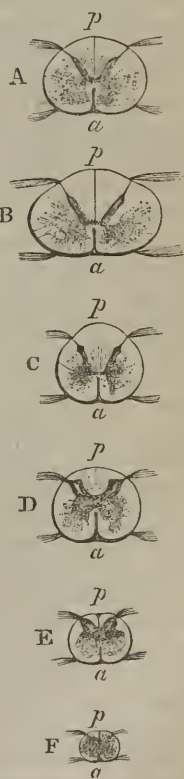


Fig. 327. Transverse section of the spinal cord:—A. Immediately below the decussation of the pyramids. B. At middle of cervical bulb. C. Midway between cervical and lumbar bulbs. D. Lumbar bulb. E. An inch lower. F. Very near the lower end. *a*. Anterior surface. *p*. Posterior surface. The points of emergence of the anterior and posterior roots of the nerves are also seen. —Todd and Bowman.]

* Op. cit. p. 285.

thin and indistinct, so that its existence has been denied by anatomists, of good authority.

At its junction with the white substance, the gray matter presents a somewhat jagged or indented outline, especially in the anterior horn of each crescent.

At the tip of the posterior horn, which is somewhat enlarged, the gray matter has a peculiar semi-transparent aspect, whence it was named by Rolando, *substantia cinerea gelatinosa.*

The white substance forms by far the larger portion (it is said nearly seven-eighths) of the cord. Owing to the peculiar arrangement of the gray matter, the white substance in each semi-cylindrical half of the cord is divided into two principal columns, which have been already noticed in describing its surface; viz., a posterior and an antero-lateral column. The posterior column, fig. 326, *p e b*, is situated between the posterior median fissure and the posterior lateral fissure with the corresponding cornu of the gray matter: it is wedge-shaped, the point of the wedge being directed forwards towards the centre. The remaining portion of white substance constitutes the antero-lateral column *a e b*, which is bounded behind by the posterior cornu of gray matter *b*, and on the inner side by the anterior median fissure *a*. It is partially subdivided by the anterior gray cornu *c*, into a lateral, *c e b*, and an anterior column, *a e c*, the latter being joined to the corresponding column of the other half of the cord by means of the white commissure.

According to this view there are three principal columns in each half of the cord, viz., an anterior, a lateral, and a posterior column, in addition to the slender tract adjoining the posterior median fissure already described, which is generally reckoned as part of the posterior column.

The white substance of the cord has been described as if disposed in thin wedge-shaped and longitudinal laminæ, placed in a radiating manner, with their edges in contact with the gray matter. Such a regular arrangement of lamellæ does not exist, but the white substance is collected into compressed longitudinal bundles, between which small blood-vessels run transversely into the substance of the cord, supported for a certain distance by delicate processes of membrane derived from the pia mater.

There is an appearance of transverse decussating bundles in the anterior commissure, but this is to be attributed to the frequent interruption of the white substance by foramina for the transmission of small blood-vessels.

The arrangement of the white and gray substances, though agreeing generally with the description just given, is somewhat modified at different parts of the cord, as may be seen in sections made at different heights. Thus, the horns of the gray crescents are long and slender in the cervical portion, fig. 327, A, B, short and more slender in the dorsal, C, and short but much wider in the lumbar region, D, E; so that the gray matter appears, in a series of sections, to be, relatively to the white, more abundant in the lumbar region of the cord, E, less so in the cervical region, A, B, and least so in the dorsal, C,

The quantity of white matter is greatest in the neck. Towards the lower end of the cord F, the double crescentic appearance gradually ceases, and the gray matter is collected into a central mass, which is indented at the sides. At its extreme point, according to Remak and Valentin, it consists of gray matter only.

In fishes, reptiles, and birds, during the whole period of life, a canal exists along the centre of the spinal cord. It is found also in the fœtus of mammiferous animals, and even in the young of that class. In the human fœtus, as shown by Tiedemann, there also exists, until after the sixth month, a central canal formed by the closing in of an open groove previously existing. In the adult human subject, the upper portion of this canal can be traced from the point of the calamus scriptorius in the floor of the fourth ventricle, for about half an inch or more down the centre of the cord, where it ends in a cul-de-sac. Much controversy, however, has prevailed in regard to the extent to which this canal exists in the adult, and many writers have maintained that it is to be found through the whole length of the cord, situated between the gray and white commissures.

The attention of anatomists has recently been directed to this point by the microscopic observations of Drs. Stilling and Wallach,* who maintain that the canal may be traced in the adult low down in the cord, appearing on a section as a small round foramen in the centre of the gray matter. We must confess that, on careful examination, we have only now and then been able to discover an aperture, which has much the appearance of a divided blood-vessel.

The minute or microscopic structure of the cord, including the arrangement of the roots of the nerves within it, will be considered afterwards.

THE ENCEPHALON.

We have now to describe the four principal parts into which the encephalon is divided, viz., the cerebrum, the cerebellum, the pons Varolii, and the medulla oblongata. But their general position within the skull, and their relations to each other, require first to be understood.

The *cerebrum*, fig. 328, A, which constitutes the highest and by far the largest part of the human encephalon, occupies the upper and larger portion of the cranial cavity. A line drawn from a little above the orbit to the auditory meatus, met by another from the occipital protuberance to the same point will nearly indicate on the living head, the inferior limit of the cerebrum. In front, it rests in the anterior fossa of the base of the skull; behind this, in the middle fossa; and still further back it overlies the cerebellum, beyond which it projects posteriorly, resting on the tentorium, a horizontal partition formed by the dura mater between the cerebrum and the cerebellum. In all this extent, as well as above and at the sides, the cerebrum is free and unattached, but from the middle of its under surface there proceeds a comparatively narrow and constricted portion, part of which, *a*, form-

* Uber die Textur des Rückenmarks. Leipzic, 1842.

ing the crura cerebri or peduncles of the brain, descends into the pons Varolii below, and through it, is continued into the medulla oblongata; whilst another part, *b*, passes down to join the cerebellum.

Fig. 328.

A plan in outline, showing, in a lateral view, the parts of the encephalon separated somewhat from each other. A. Cerebrum. *f, g, h.* Its anterior, middle, and posterior lobes. *e.* Fissure of Sylvius. B. Cerebellum. C. Pons Varolii. D. Medulla oblongata. *a.* Peduncles of cerebrum. *b.* Superior; *c.* Middle; and *d*, Inferior peduncles of cerebellum. The parts marked *a, b, c,* C, form the isthmus encephali.

The *cerebellum*, B, is placed beneath the hinder part of the cerebrum, by which it is completely overlapped, the tentorium separating one from the other. It is lodged in the inferior occipital fossæ, and is attached to the rest of the encephalon, at its fore part, by means of connecting portions named *crura:* of these, two, *b*, ascend to the cerebrum, two, *d*, pass downwards to the medulla oblongata, D, and two, *c*, horizontally forwards, so as to embrace the peduncles of the brain, in front of which they unite to form the transverse eminence of the *pons Varolii.*

The *pons*, C, itself rests upon the upper part of the basilar process, in front; it receives the cerebral peduncles above, and the middle crura of the cerebellum behind and at the sides; whilst the medulla oblongata is connected with it below.

Lastly, the *medulla oblongata*, D, descending obliquely backwards from the lower border of the pons, is placed beneath the middle of the cerebellum, and rests on the basilar groove, until it reaches the foramen magnum, where it is continuous with the spinal cord, *t*.

Situated in the interior of the brain, surrounded by nervous substance and lined by a delicate membrane, are certain serous cavities, called *ventricles.* These, which are five in number, will be described with the parts of the encephalon in which they occur.

We shall now proceed to describe those parts in the following

order: the medulla oblongata, the pons Varolii, the cerebrum, and the cerebellum.

THE MEDULLA OBLONGATA.

The *medulla oblongata*, fig. 331, *v*, is that part of the encephalon which is immediately connected with the upper end of the spinal cord. It is bounded above by the lower border of the pons Varolii, whilst it is continuous below with the spinal cord, opposite the foramen magnum. By some, its inferior limit is, with reason, fixed rather lower down, on a level with the upper border of the atlas, at a point which corresponds with the lower extremity of the anterior pyramids, to be presently described.*

The medulla oblongata inclines obliquely downwards and backwards, fig. 332, towards the foramen magnum. Its anterior surface rests in the basilar groove, whilst its posterior surface is received into the fossa, named the vallecula, between the hemispheres of the cerebellum, and there forms the floor of the fourth ventricle. To its sides, several large nerves are attached, fig. 331.

It is of a pyramidal form, fig. 329, having its broad extremity turned upwards, from which it tapers to its point of connexion with the spinal cord: it is expanded laterally at its upper part. Its length from the pons to the lower extremity of the pyramids is about an inch and a quarter; its greatest breadth is about three quarters of an inch; and its thickness, from before backwards, about half an inch.

The pia mater having been removed, the medulla oblongata is seen to be marked longitudinally by an anterior and a posterior fissure, which are continuous with those of the spinal cord. Of these, the *anterior*, between *a a*, terminates immediately below the pons *p*, in a cul-de-sac, called the foramen cœcum, by Vicq-d'Azyr. It is penetrated by a fold of the pia mater.

The *posterior* fissure, fig. 330, is deep but narrow; it is continued upwards into the floor of the fourth ventricle, *v v'*, where it becomes a superficial furrow and is gradually lost.

By means of these two fissures, the medulla oblongata is partially divided like the cord, into two lateral and symmetrical halves. But here the resemblance ceases; for on each side of the median line an entirely new arrangement prevails; the lateral fissures disappear, and the surface of each half of the medulla presents four eminences or columns, which, on commencing at the anterior fissure and proceeding backwards each way to the posterior fissure, are met with in the following order: the anterior pyramids, the olivary bodies, the restiform bodies, and the posterior pyramids.

The *anterior pyramids*, fig. 329, *a a*, so called from their position and shape, are two bundles of white substance, placed on either side of the anterior fissure, which are narrower at the lower end, and become broader and more prominent as they ascend towards the pons

* The term medulla oblongata, as employed by Willis, by Vieussens, and by those who directly followed them, included the crura cerebri and pons Varolii, as well as that part between the pons and the foramen magnum, to which, by Haller first, and by most subsequent writers, this term has been restricted.

Varolii. At their upper end they are constricted, and thus enter the substance of the pons, *p*, through which their fibres may be traced into the peduncles of the brain. The outer border of each pyramid is marked off from the olivary body, *c*, by a slight depression. By their inner borders the pyramids form the sides of the anterior fissure. Over a space, commencing about eight or ten lines below the pons and extending to the lower end of the medulla, a portion of each pyramid, arranged in several bundles, passes downwards across the fissure to the opposite side. This *decussation of the pyramids*, *b*, as it is called,

Fig. 329.

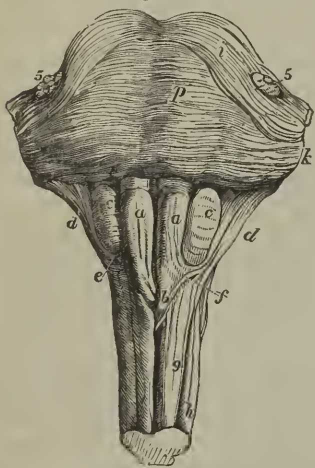


Fig. 330.

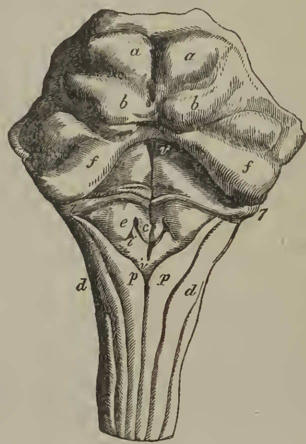


Fig. 329. An anterior view of the medulla oblongata. *a a*. Anterior pyramids. *b*. Their decussation across the middle line. *c c*. The olivary bodies. *d d*. Restiform bodies. *e*. Arciform fibres. *f*. Fibres shown by Solly to pass from the anterior column of the cord to the cerebellum. *g*. Anterior column. *h*. Lateral column. *p*. Pons Varolii. *i*. Its upper fibres. 5, 5. Roots of fifth nerves.

Fig. 330. Posterior view of the medulla oblongata, and back of the pons Varolii. The peduncles of the cerebellum are cut short. *d d*. Restiform bodies, (fasciculi cuneati,) passing up to become inferior peduncles of cerebellum. *p p*. Posterior pyramids. *v v'*. Posterior fissure, or calamus scriptorius, extending along the floor of the fourth ventricle. *a a*. Testes. *b b*. Nates. *f f*. Superior peduncles of cerebellum. *c*. Eminence connected with hypoglossal nerve. *e*. With glosso-pharyngeal nerve. *i*. With vagus nerve. *v'*. With spinal accessory nerve. 7, 7, Roots of auditory nerves.

is partial, for it affects only the innermost fibres, and consists of from three to five intersecting bundles from either side. When traced from below, it is found that the whole, or a great part of these fibres come forwards from the deep portion of the lateral columns of the cord (as appears first to have been pointed out by Rosenthal),* and advance to the surface, between the diverging anterior columns, *g g*, which are thus thrown aside.

The outer portion of each pyramid does not decussate;† it consists of fibres, derived from the anterior column of the cord: these all as-

* Ein Beytrag zur Encephalotomie, 1815.

† The decussation of the anterior pyramids was noticed about the beginning of the last century by Mistichelli. Though doubted by Morgagni, Haller, Vicq-d'Azyr, and many others, it is a well-established fact, and has been supposed to afford some explanation of the cross effect of certain injuries and diseases of the brain.

cend and are joined by the decussating portion from the opposite side. Together they form a prismatic bundle or column of white fibres, which extends deeply into the substance of the medulla, and is triangular in a cross section, (see fig. 339, *b*.)

The anterior pyramids contain no gray matter.

The *olivary bodies* (olivæ, seu corpora olivaria), fig. 329, *c c*, are two prominent oval masses placed to the outer side of the pyramids and sunk to a considerable depth in the substance of the medulla oblongata, appearing on its surface like two smooth oval eminences. They are placed parallel to the outer border of the pyramids, and therefore incline outwards towards their upper end. They do not reach the pons Varolii above, being separated from it by a deep depression; nor do they extend so far in a downward direction as the pyramids, than which they are considerably shorter.

The olivary bodies consist externally of white substance, of which the fibres chiefly run longitudinally; and internally of a gray nucleus, named *corpus dentatum* or *ciliare*.

On making a section, whether horizontal or vertical, this gray matter which is of a light yellowish colour, appears in form of a zigzag line, circumscribing a whitish substance within, and interrupted towards the centre of the medulla, (see figs. 339, *c*, 340, *q*). The gray matter or nucleus of the olivary body therefore is arranged in the form of a pouch or capsule, which is open at its upper and inner part and has its sides corrugated or plicated, so as to give the indented appearance to a section, from which its name has been derived. This pouch is, moreover, surrounded with white matter externally, and through its open part white fibres pass into or issue from its interior, and connect it with other parts of the brain. The external fibres of the anterior columns of the cord, which are here thrown outwards, as already mentioned, are continued upwards, on the surface of the medulla oblongata, and then pass partly on the outside and partly beneath the olivary bodies—being joined in their further progress by the fibres issuing from the olivary nucleus. To these fibres on each side, the term olivary fasciculus has been applied.

The *restiform bodies* (corpora restiformia). Behind and to the outer side of the olivary body, are two lateral rounded eminences or columns, called from their rope-like appearance, the *restiform bodies*, fig. 329, *d d*. These are directly continuous with the posterior, and with part of the antero-lateral columns of the cord; they diverge slightly as they ascend, and thus occasion the great width of the medulla at its upper part. Each of them passes into the corresponding hemisphere of the cerebellum, and constitutes its inferior peduncle.

The restiform bodies are well seen, on a posterior view, fig. 330, *d d*. First, they are in contact with the small tracts of the medulla, named the posterior pyramids, *p*; but higher up they become free and prominent, and assist in forming the lateral boundaries of the fourth ventricle.

By far the larger portion of the external white substance of the restiform body consists of longitudinal fibres, which include all those belonging to the posterior column of the cord, except the fasciculi

graciles, *p*, some derived from the lateral column, and also a small band from the anterior column. This last-named band, fig. 329, *f*, runs obliquely below the olivary body and connects the anterior column with the cerebellum, as was first shown by Mr. Solly.*

The part of the posterior column of the cord which belongs to the restiform body of the medulla, is named the fasciculus cuneatus by the German anatomists: below *d*, on the right side.

There is a considerable portion of gray matter in the interior of the restiform body. This is for the most part much diffused; but one large mass, fig. 330, *d*, continuous below with the substantia gelatinosa, or gray matter forming the posterior cornu of the cord, is thrown out towards the side of the medulla, and generally appearing as a longitudinal streak at the surface, forms the gray tubercle of Rolando (tuberculo cinereo).

The *posterior pyramids* (fasciculi graciles), *p p*, fig. 330, of the medulla oblongata, are the smallest of the four columns into which it is divided. They are situated in contact with each other, one on either side of the posterior median fissure. They consist entirely of white fibres, and are continuous with the posterior slender tracts already described as existing on the posterior median aspect of the cord. On reaching the lower part of the medulla, the posterior pyramids become somewhat swelled out, and then, diverging from one another, they become closely applied to the restiform bodies, and have been considered to be blended with them, and therefore to contribute to form the inferior peduncles of the cerebellum. But, according to Burdach and Arnold, these small columns ascend to the cerebrum.

The triangular portion of the back of the medulla, which is bounded on each side by the diverging posterior pyramids below, and by the restiform bodies higher up, constitutes the floor of the fourth ventricle, that part of it, namely, which is called the *calamus scriptorius*, *v'*. Upon it, the gray matter of the centre of the medulla oblongata is, as it were, opened out to view. It is marked by a median furrow *v v'*, and at its lower end is a tubular recess, or cul-de-sac, passing down the centre of the medulla for a few lines. This, which has been sometimes named the *ventricle of Arantius*, is all that remains in adults of the central canal of the spinal cord already spoken of.

In the upper part of the floor of the ventricle are two longitudinal eminences, one on each side of the middle furrow. These are formed by two bundles of white fibres, mixed with much gray matter, the *fasciculi teretes* of some authors, *les faisceaux innominés* of Cruveilhier. They seem to be derived from part of the lateral columns of the cord; Cruveilhier believes, however, that they arise from the gray matter at the lower end of the medulla oblongata.

The mode in which the columns of the spinal cord are re-arranged so as to form those of the medulla oblongata, has been incidentally alluded to in the foregoing description; but the subject will be hereafter resumed in considering the internal structure.

Santorini, and subsequently Rolando, described a set of superficial

* Phil. Trans. for May, 1836.

white fibres on the fore part and sides of the medulla oblongata, crossing over it below the olivary bodies. From their direction they were named *fibræ vel processus arciformes*, fig. 329, *e*. They belong to a system of white fibres which pass transversely or horizontally, and consequently across the direction of the longitudinal columns already described. Part of them run from behind forwards in the median plane, forming a sort of septum between the lateral halves of the cord, and have been named *septal* fibres, fig. 340, *c*. It is probable that the arciform fibres are a continuation of these central fibres in front; and there is also reason to suppose that they form the transverse medullary white striæ, in the floor of the fourth ventricle, which are connected with the origin of the auditory nerves, fig. 330,[7] [7], and which will hereafter be described.

Sometimes the greater part of the pyramidal and olivary bodies is covered by a thin stratum of these transverse fibres, which appear to issue from the anterior median fissure; but, most commonly, these superficial fibres appear only at the lower extremity of the olive, as the arciform fibres already mentioned. These differences are, most probably, owing not to the presence of the fibres at one time, and their absence at another, but to the circumstance of their running sometimes superficially, and at other times deeply in their transverse course.

THE PONS VAROLII, OR TUBER ANNULARE.

The *pons Varolii*, or *annular protuberance* (tuber annulare), fig. 329, *p*, fig. 331, *o*, is a comparatively small portion of the encephalon, which occupies a central position on its under surface, above and in front of the medulla oblongata, below and behind the crura cerebri, and between the middle crura of the cerebellum, with all which parts it is connected. From its position and connexions it has been named méso-céphalon (Chaussier), and nodus encephali (Rau, Sœmmerring).

The under surface of the pons Varolii is of course seen in the base of the brain, fig. 331, *o*, whilst its upper surface, or the back, continuous with that of the medulla oblongata, forms part of the floor of the fourth ventricle, fig. 330.

The under surface forms a white transverse quadrangular eminence, fig. 329, *p*, fig. 331, *o*, projecting in relief beyond the level of the medulla oblongata and crura cerebri, which, as we shall see, are connected with each other through its substance. It is this part, in particular, which is named the *annular protuberance*, because it embraces, as in a ring, the longitudinal portions of the nervous axis,—and also the *pons*, because, when viewed from below, it seems to cross over those parts like a bridge.

It rests on the upper part of the basilar groove. It is marked with transverse bands and striæ, which indicate the course of its superficial fibres. Along the middle line it presents a shallow longitudinal groove, which is wider in front than behind, and is prolonged over the anterior and posterior borders of the pons. The basilar artery runs along this groove, in the floor of which are perforations for the transmission of small branches of that vessel.

The anterior and posterior borders of the pons are well defined.

The anterior is more extended than the posterior, and its outline is more convex from side to side.

The crura cerebri, fig. 331, *d*, *t*, appear to emerge from beneath it. At the sides, the limits of the pons Varolii are quite arbitrary, for it merely becomes narrower owing to its being gathered, as it were, into a compressed bundle on each side *l*. These two bundles pass obliquely outwards and backwards into the cerebellum, and form its middle peduncles.

The substance of the pons Varolii consists of transverse and longitudinal white fibres interspersed with a quantity of diffused gray matter. The transverse fibres, with a few exceptions to be particularized hereafter, enter the cerebellum under the name of the middle crura or peduncles, and form a commissural system for its two hemispheres. The longitudinal fibres are those which ascend from the medulla oblongata into the crura cerebri, augmented, it would seem, by others which arise within the pons from the gray matter scattered through it. The arrangement of both these sets of fibres in the interior of the pons will be referred to hereafter; but we may notice now the layer of transverse fibres, fig. 329, which are next the surface. The fibres composing this layer do not all run parallel to each other. The middle fibres pass directly across, the lower set ascend slightly, whilst the upper fibres, which are the most curved, descend obliquely to reach the crura cerebelli on each side. There is always one superficial band, *i*, of the superior fibres, which crosses obliquely downwards over the middle and lower fibres, to gain the anterior surface of the corresponding crus.

THE CEREBRUM.

The *cerebrum* or brain proper, fig. 328, A, as already mentioned, is the highest, and by far the largest portion of the encephalon. It is of an ovoid shape, but is irregularly flattened on its under side. It is placed in the cranium with its small end forwards, its greatest width being opposite to the parietal eminences.

The cerebrum consists of two lateral halves, or *hemispheres*, as they are called, which, though connected by a median portion of nervous substance, are separated in a great part of their extent by a fissure, named the great longitudinal fissure, which is seen on the upper surface of the brain and partly also upon its base, fig. 331, *a x b*.

The cerebral hemispheres are not plain and uniform upon the surface, but are moulded into numerous smooth and tortuous eminences, named *convolutions* or gyri, which are marked off from each other by deep furrows, called sulci, or *anfractuosities*. These convolutions are coloured externally; for the surface of the cerebral hemispheres, unlike the parts hitherto described, is composed of gray matter.

Upper surface of the cerebrum.—The *great longitudinal fissure*, seen upon the upper surface of the brain, extends from before backwards throughout its whole length in the median plane, and thus separates the cerebrum, as already stated, into a right and left hemisphere. On opening this fissure, it is seen, both before and behind, to pass quite through to the base of the cerebrum; but in the middle it is interrupted by a transverse portion of white substance, named the *corpus callosum*,

fig. 332, *a b*, which connects the two hemispheres together. In the natural state, this fissure is occupied by a vertical process of the dura mater—the falx cerebri,—which dips down between the two hemispheres, not quite reaching to the corpus callosum.

Each cerebral hemisphere has an outer or convex surface, which is in contact with the vault of the cranium, an inner or flat surface, of a crescent shape, which forms one side of the longitudinal fissure; and an irregular under surface, which rests on the base of the skull, and on the tentorium cerebelli.

Under surface of cerebrum.—The under surface of each hemisphere, fig. 331, is marked off into three parts, called *lobes*, which are named according to their position, anterior, middle, and posterior, A B C, also *f g h*, fig. 328. The division between the anterior and middle lobes, which is very distinct, is indicated by a deep cleft, named the Sylvian fissure, *s s'*. There is no such evident demarcation between the middle and posterior lobes; but anatomists have considered as the posterior lobe, that part of the hemisphere which lies over the cerebellum.* The under surface of the anterior lobe is triangular and excavated to adapt it to the roof of the orbit on which it rests. The middle lobe, fig. 328, *g*, is rounded and prominent, and occupies the middle fossa of the skull—the edge of the lesser wing of the sphenoid bone corresponding with the Sylvian fissure. The posterior lobe, *h*, is smooth and slightly concave on its under surface, where it rests on the arch of the tentôrium.

The Sylvian fissure, fig. 328, *e*, 331, *s s'*, which separates the anterior and middle lobes, passes at first upwards and backwards in the outer part of the hemisphere, and divides into two branches. At the entrance of the fissure is seen a bundle of white substance passing from the anterior to the middle lobe, named *fasciculus unciformis* (Reil).

On opening the fissure out, there is exposed to view a triangular prominent portion of the cerebral mass, named the *island of Reil* (insula). It is marked by small and short convolutions, which are sometimes called *gyri operti*, because in the natural state of the parts they are covered by the sides of the fissure.

It has already been stated that the entire surface of the cerebral hemispheres is marked by *convolutions* and sulci, some of which, it must not be forgotten, are concealed from view in the great fissures. These convolutions do not exactly resemble each other in all brains, nor are they symmetrical on the two sides of the same brain, although there is a certain correspondence in their general direction.

Each convolution may be described as presenting a summit or rounded free border, two sides, and a base, by which it is connected with the general cerebral mass. The outer portion of the convolutions (including, of course, the sides and bottom of the sulci) consists of a layer of gray matter, which is here called the *cortical substance* or *layer:* they are covered closely throughout by the pia mater, a vascular membrane, which sends processes down to the bottom of the sulci between them. These sulci are generally about an inch deep; but in

* It is right to remark that some anatomical writers admit only *two* lobes, reckoning the middle and posterior lobes as a single one, under the name of the posterior lobe.

this respect there is much variety in different brains, and in different parts of the same brain; in other words, the depth of the convolutions varies considerably: those upon the outer convex surface of the hemisphere are the deepest. In general, the depth of a convolution exceeds its width; and its width, near the summit, is greater than through its base.

The free border of a large convolution, or the side of an unusually deep one, is sometimes grooved longitudinally, or marked with shallow notches, so as to be partially divided into smaller or subordinate gyri. All the convolutions are continuous with each other, if not upon the surface, at least within the anfractuosities; for, if one appears to end abruptly, it will be found on examination to sink between and then run into others, across the bottom of the intervening sulci.

Since the external gray or cortical substance is continuous over the whole surface of the cerebral hemispheres, being found alike within the sulci and upon the gyri, a far greater extent of gray matter is obtained with a given size of the organ than could have been the case, had the hemispheres been plain and destitute of convolutions.

The general arrangement of the convolutions has been made the subject of study by various anatomists in earlier and recent times, but much yet remains to be elucidated. An attempt to describe individual gyri would be quite useless, owing to their irregularity in different cases, and their want of symmetry in the same brain. Nevertheless, there are some sufficiently constant in presence, and characteristic in situation and form, to admit of being specially described.

It has also been shown that certain of the cerebral convolutions precede others in their appearance in the series of mammiferous animals; for in the lowest mammalia, and in all inferior classes of vertebrata, the cerebrum is not convoluted on the surface.

Among the earliest convolutions to appear are those of the island of Reil, which are concealed in the Sylvian fissure. As seen in the human brain, they radiate from the summit to the base of the triangular eminence formed by the island, and are separated by shallow sulci.

Surrounding the convolutions of the island (gyri operti), and forming the lips of the Sylvian fissure, is a very large convolution, named *convolution of the Sylvian fissure.* This is also early in its appearance in animals: in them it is, at first, simple in form, and completely surrounds the fissure, forming a curve, open in front and below. In the human brain, fig. 331, *f f*, it is tortuous and much folded, so as to form many subordinate gyri, corresponding with the front, upper, and under border of the fissure. The commencement of this convolution, *f*, in front of the fissure, forms the outer part of the triangular orbital surface of the anterior lobe. From its outer border proceed numerous secondary gyri, which extend in various directions on the convex surface of the hemisphere, fig. 328; and its inner border receives, in a similar manner, the radiating convolutions of the island of Reil.

Perhaps the most distinct and symmetrical convolution in the whole brain is that named the *internal convolution, convolution of the corpus callosum, gyrus fornicatus.* Commencing (fig. 332, *h*), on the under surface of the brain, immediately before the part named the anterior

perforated space, it ascends a short distance in front of the anterior recurved extremity of the corpus callosum, a, and then runs backwards, h' immediately above that body, as far as its posterior extremity: there it turns downwards and forwards, h'', embracing the cerebral peduncle, fig. 331, t, to reach the entrance of the Sylvian fissure, h'. This long convolution, therefore, describes a sort of ring open or interrupted opposite the Sylvian fissure, and embracing the corpus callosum above, and the cerebral peduncle below. It thus occupies the entire margin of the convoluted surface of the hemisphere, and, as was pointed out by Foville, forms a sort of rim or border to the gray matter, whence it is named by him *convolution d'ourlet.* The surface of this convolution, especially towards its termination below, is covered by a very thin cribriform layer of white substance, which, with the gray matter beneath, gives the surface a mottled aspect. This has been called the *reticulated white substance.* The gyrus fornicatus is variously grooved in different brains, and from its upper border are given off secondary gyri, which extend in different directions upon the inner or flat surface of the hemisphere, fig. 332. From the appearance of the convolution and its offsets in this situation, the name *processo cristato* was applied to it by Rolando.

Another large convolution may be traced, according to Foville, more or less indented or interrupted, however, in its course, along the line of junction between the convex and flat surfaces of the hemisphere,—in other words, along the corresponding lip of the great longitudinal fissure. This, which might be called the *marginal convolution of the longitudinal fissure*, commences on the under surface of the brain (figs. 331, 332, x), in common with the gyrus fornicatus, and passing forwards, forms the inner border of the triangular orbital surface of the anterior lobe, and is here cleft as it were into two by a deep sulcus, into which the olfactory nerve 1, is received. Turning next over the front and upper surface of the cerebrum, it may generally be traced for some distance along the margin of the longitudinal fissure x' x'', but soon becomes marked by deep sulci; and thus interrupted, may be followed round the posterior extremity y, and afterwards along the under surface of the hemisphere forwards as far as the point of the middle lobe, running parallel for some space with the under portion of the gyrus fornicatus.

The convolutions on the under surface of the anterior lobe have been usually mentioned separately by anatomists. The outer border, fig. 331, of this triangular surface is formed by the commencement of the convolution of the Sylvian fissure f; the inner border, x, by the marginal convolution of the longitudinal fissure, in the sulcus on which the olfactory nerve is lodged. The intermediate excavated part is occupied by other convolutions, less regular in their direction. At the apex of the triangle behind, the two borders are connected by a short and but slightly elevated convolution, s, which bounds the anterior perforated space in front.

It remains only to notice those gyri which occupy the outer or convex surface of the hemisphere, between the marginal convolution

of the longitudinal fissure and that of the Sylvian fissure. The general direction of these, see fig. 328, *f h g*, which are the largest, the most complicated, and the least symmetrical of all the convolutions of the human brain, is not longitudinal, like those previously described, but transverse or somewhat oblique. It has been remarked by Foville that they frequently become branched like the letter Y, as they proceed upwards and backwards towards the longitudinal fissure.

M. Foville considers that the convolutions may be arranged into four principal groups or orders, founded in a great measure on their relative connexions with the anterior perforated space, which, in his estimation, is a part of the highest importance.

The *first* order issues from the perforated space, and consists of two portions. One, large and vertical, is the gyrus fornicatus, minus its ascending secondary gyri; the other, short and horizontal, is the slightly elevated ridge which bounds the perforated space, in front and on the outer side.

The *second* order, also consisting of two portions, commences from the horizontal portion of the first order, on the limits of the perforated space. One part corresponds with the marginal convolution of the longitudinal fissure, as already described, except that part of it on the orbital surface of the anterior lobe, which lies to the outer side of the olfactory sulcus; the other part is the convolution of the Sylvian fissure.

The *third* order consists of two sets, of which one occupies the inner surface of the hemisphere, and connects the gyrus fornicatus in its whole length with the marginal convolution of the longitudinal fissure; the other set lies in the Sylvian fissure, forms the island of Reil, and connects the short horizontal portion of the first order with the convolution surrounding that fissure.

The convolutions of the *fourth* order, the largest, deepest, and least symmetrical of all, are quite detached from the perforated space, and have no relation to the first order of convolutions. They connect the two convolutions of the second order together, viz., the marginal convolution of the median fissure and that of the Sylvian fissure, and occupy the outer or convex surface of the cerebral hemisphere.

M. Leuret has arrived at some interesting conclusions in reference to the cerebral convolutions in mammalia, which class of animals are arranged by him, in connexion with this point, into as many as fourteen groups.

In the lowest group—represented by the bat, mole, rat, &c.—the cerebral hemispheres, as in birds, are quite plain and smooth, though divided by a Sylvian fissure. In the second group—including the rabbit, beaver, and porcupine—that fissure is more strongly marked; but there are only a few slight depressions on the surface of the hemispheres, indicating the future sulci between the convolutions.

In the third group—formed by the fox, wolf, and dog—the simplest form of true convolutions is first met with; and they are named by M. Leuret, *fundamental convolutions*. In the brain of the fox, taken as a typical example, they are six in number: they are all simple in outline, distinct from each other, and form a series of longitudinal curved lines on the surface of the hemisphere, running from before backwards.

Four of them, named *external*, are placed on the convex surface of the hemisphere. Of these, one forms the curved lip or border of the Sylvian fissure, and surrounds the island of Reil; the other three, also curved in this direction, are placed parallel with the first, and one above another,—the fourth, or *superior* convolution, being placed on the margin of the longitudinal fissure. The fifth convolution (*anterior*) forms the under and fore part of the anterior lobe, and is named the supra orbital convolution. The sixth (*internal*) is placed above the corpus callosum, and corresponds with the gyrus fornicatus.

In the succeeding groups, up to the thirteenth, various changes take place in the condition and mode of connexion of these fundamental convolutions, which cannot be detailed here. Thus, in all cases excepting in the feline tribe, they are reduced in number to five, or four—the reduction affecting the external convolutions. In some cases they are bifurcated at certain points, or marked by

divisions or depressions, or they are undulated in their course. Lastly, they are very commonly united, at more or less frequent intervals, by short *supplementary* convolutions.

In the brain of the elephant (which stands in the thirteenth group) M. Leuret recognises another additional set of convolutions, which have a more decidedly transverse direction than the short supplementary convolutions above alluded to. These new convolutions (*superior transverse*), forming two rows and separated by a groove, occupy the upper and outer part of the hemisphere, and cross or interrupt, as it were, the fundamental longitudinal convolutions.

In the last group (that of the monkeys) these *superior* transverse convolutions, forming two distinct rows, separated by an intermediate groove, are still more evident.

In the human cerebrum, M. Leuret, by help of a comparison between the brain of the fœtus and the adult, has represented three external fundamental convolutions, which are tortuous, and frequently communicate with each other. Besides these, there is the internal convolution (gyrus fornicatus) and supra-orbital convolution (?).

Between the anterior and posterior portions of the three external convolutions, are interposed, on the upper surface of the brain, two sets of *transverse* convolutions, divided by a distinct sulcus, which runs outwards and forwards from the longitudinal fissure, so that the right and left grooves form a V-shaped line, open in front. This fissure, also noticed in the brains of the elephant and monkey, is stated by Leuret to be very constant, and is named by him the fissure of Rolando.*

From the preceding account of the cerebral convolutions, it would appear that those situated upon the outer or convex surface of the hemisphere—the fourth order of M. Foville, and the superior transverse convolutions of M. Leuret—attain their highest development in man, and are indeed particularly characteristic of the human brain. To this peculiarity, however, must be added, the elongation of the cerebrum backwards by the increased development of the posterior lobe, and the greater complexity of the vertical convolutions in the median fissure, and of those of the island of Reil.

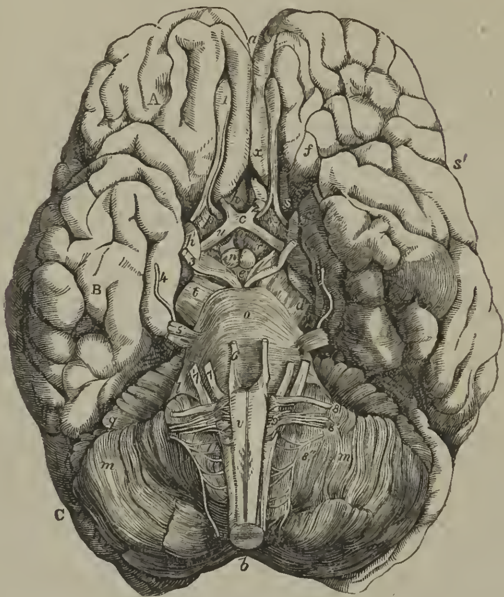
Base of the cerebrum, fig. 331.—When the brain is turned with its base uppermost, and the parts of which it is composed are allowed to fall asunder by their own weight, two large bundles, *d*, *t*, consisting of white substance externally, are seen to emerge together from the fore part of the pons Varolii, *o*, and, separating from each other as they proceed forwards and outwards, to enter the inner and under part of the right and left cerebral hemispheres. These white bundles, which are marked on the surface with longitudinal striæ, are the *peduncles* (crura) of the cerebrum. Just before entering the corresponding hemisphere, each is crossed by a flattened white cord, named the *optic tract*, *u u*, which, adhering by its upper border to the peduncle, is directed forwards and inwards, and meets in front with its fellow of the opposite side to form the optic commissure, *c*, from the fore part of which the optic nerves 2, 2, proceed.

Limited behind by these diverging peduncles, and in front by the converging optic tracts, is a lozenge-shaped interval, called the *interpeduncular space*, in which are found the following parts:—the poste-

* In the Hunterian Lectures for 1842, Professor Owen gave the results of his observations on the comparative anatomy of the convolutions. He had previously, in 1833, called attention to this study as a means of determining "the amount and locality of the convolutions of the human brain which are analogous to those of the lower animals." On the anatomy of the Cheetah; Zoological Trans. vol. i.

rior perforated space, the corpora albicantia, the tuber cinereum, infundibulum, and pituitary body.

Fig. 331.



Shows the under surface or base of the encephalon freed from its membranes—A, anterior, B, middle, and C, posterior lobe of cerebrum.—*a*. The fore part of the great longitudinal fissure. *b*. Notch between hemispheres of the cerebellum. *c*. Optic commissure. *d*. Left peduncle of cerebrum. *e*. Posterior perforated space. *e* to *i*. Interpeduncular space. *f f′*. Convolution of Sylvian fissure. *h*. Termination of gyrus fornicatus behind the Sylvian fissure. *i*. Infundibulum. *l*. Right middle crus or peduncle of cerebellum. *m m*. Hemispheres of cerebellum. *n*. Corpora albicantia. *o*. Pons Varolii, continuous at each side with middle crura of cerebellum. *p*. Anterior perforated space. *q′*. Horizontal fissure of cerebellum. *r*. Tuber cinereum. *s s′*. Sylvian fissure. *t*. Left peduncle or crus of cerebrum. *u u*. Optic tracts. *v*. Medulla oblongata. *x*. Marginal convolution of the longitudinal fissure.—1 to 9 indicate the several pairs of cerebral nerves, numbered according to the usual notation, viz., 1. Olfactory nerve. 2. Optic. 3. Motor nerve of eye. 4. Pathetic. 5. Trifacial. 6. Abducent nerve of eye. 7. Auditory, and 7′. Facial. 8. Glosso-pharyngeal, 8′. Vagus, and 8″. Spinal accessory nerve.

Immediately in front of the pons is the *posterior perforated space* (locus perforatus posterior), *e*, a deep fossa situated between the peduncles, the bottom of which is composed of grayish matter, connecting the diverging crura together, and named pons Tarini. It is perforated by numerous small openings for the passage of blood-vessels; and some horizontal white striæ usually pass out of the gray matter and turn round the peduncles immediately above the pons.

In front of this fossa are two round white eminences, each about the size of a pea, placed one on either side, surrounded by gray matter, and connected together across the middle line. These white bodies (*corpora albicantia*—corp. mammillaria), *n*, are formed, as will hereafter be seen, by the anterior extremities of the fornix, a part situated in the interior of the brain: hence they have also been named *bulbs of the fornix*. In the fœtus they are at first blended together,

and become separated about the beginning of the seventh month. In most vertebrate animals there is but one white eminence, or corpus albicans, in this position.

The interval between the corpora albicantia and the optic tracts is occupied by a soft and slightly prominent mass of gray substance, the *tuber cinereum* (Sœmmerring), *r*, which is connected with the surrounding parts of the cerebrum, and shuts in the third or middle ventricle below, forming part of what is termed the floor of that cavity. From the middle of the tuber cinereum is prolonged a conical process of a reddish colour, directed downwards and forwards, and about two lines in length, named the *infundibulum*, *i*, also fig. 332, *i*, to the summit of which is attached the *pituitary body*, *p*. This gray prolongation, from the tuber cinereum, is hollow at its base, and for a short distance downwards, and its cavity communicates above with the third ventricle—whence its name *infundibulum* (funnel).

The *pituitary body*, fig. 332, *p*, formerly called pituitary gland, from its being erroneously supposed to discharge *pituita* into the nostrils, is a small reddish-gray mass, of a somewhat flattened oval shape, being widest in the transverse direction. In the natural position of the brain it occupies the sella turcica of the sphenoid bone. It consists of two lobes, of which the anterior is larger, and concave behind, where it embraces the smaller posterior lobe. Its weight is from five to ten grains. In the adult it is solid, and its general structure is firm.

The anterior lobe consists of two kinds of matter, one hard and gray, the other, situated within, softer and of a yellowish-white colour. The posterior lobe is darker and redder than the anterior. Both are very vascular; but they have no ducts, nor, indeed, any other glandular character.

In the fœtus, the pituitary body is proportionally large, and contains a cavity which communicates, through that of the infundibulum, with the third ventricle.

The tuber cinereum, as already mentioned, is bounded before by the *optic commissure*, which, together with the optic tracts, will be fully noticed under the description of the optic nerve.

Still confining our attention to the parts in the middle line of the base of the brain, we observe in front of the optic commissure, the anterior portion of the great longitudinal fissure, which reaches down between the hemispheres in this situation. At a short distance in front of the commissure, this fissure is crossed by a white transverse mass, which is the anterior recurved extremity of the corpus callosum. On gently turning back the optic commissure, a thin connecting layer of gray substance, the *lamina cinerea*, fig. 332, behind *h*, is seen proceeding backwards from the corpus callosum to the commissure, to become continuous (supposing the parts in their natural position) above the commissure with the gray matter of the tuber cinereum. This thin gray layer, which is also connected at the sides with the gray substance of the anterior perforated space to be presently described, forms part of the anterior boundary of the third ventricle: it is very generally torn in removing the brain from the skull; and in that case, an aperture is made into the fore part of the third ventricle.

In front of the optic tract, and near the entrance of the Sylvian fissure, there is situated a grayish quadrangular space on each side, named the *anterior perforated space* (locus perforatus anticus), fig. 331, *p p*.

Each anterior perforated space is bounded in front by the convolutions of the anterior cerebral lobe, on which are seen the roots of the olfactory nerve, 1; behind, by the optic tract; on the outer side, by the middle lobe, and the commencement of the Sylvian fissure; and on the other side by the median fissure and the lamina cinerea. It is placed immediately beneath the corpus striatum, a large mass of gray matter in the interior of the brain, to be hereafter noticed. The gray surface of each perforated space is crossed by a broad white band, which may be traced from the middle of the under surface of the corpus callosum in front, backwards and outwards along the side of the lamina cinerea towards the entrance of the Sylvian fissure. These bands on the two sides are named the *peduncles of the corpus callosum.* The anterior perforated space, especially that part of it next the Sylvian fissure, is pierced with a multitude of small holes for the passage of blood-vessels, most of which are destined for the corpus striatum.

When the entire encephalon is viewed from below (as in fig. 331), the back part of the under surface of the cerebrum is concealed by the cerebellum, *m*, and the pons Varolii, *o*. If, however, these parts be removed, it will be seen that the two hemispheres of the cerebrum are separated behind as they are in front, by the descent of the great longitudinal fissure between them, and this fissure is arrested by a cross mass of white substance, forming the posterior end of the corpus callosum. This posterior part of the great longitudinal fissure is longer than the anterior portion.

INTERNAL PARTS OF THE CEREBRUM.

Having completed the survey of the parts seen externally upon the cerebrum, we proceed to examine its internal anatomy. This will be more readily understood in detail, if some general idea be previously obtained of it.

The hemispheres, it will be remembered, are connected together in the middle by the corpus callosum, and it is obvious that the structures filling up the interpeduncular space, serve also as connecting media. Between the corpus callosum above and the peduncles below, the two hemispheres are partially separated from each other, so as to leave an interval, the general ventricular space, across which some slighter connecting portions of nervous substance pass from one hemisphere to another.

Again, as seen on a transverse vertical section of the cerebrum, fig. 343, the peduncles, *b*, *g*, diverge as they ascend towards the hemispheres, and pass on each side through two large masses of gray matter, sometimes called ganglia of the brain,—at first through the thalamus opticus, *l*, and afterwards through a much larger mass, named corpus striatum, *k*. These two masses of gray matter project somewhat, as smooth convex eminences, on the upper and inner

surface of the diverging fibres of the peduncles. Immediately above the thalami and corpora striata, the hemispheres are connected together across the median plane by the corpus callosum, *q*; and it is between the under surface of the latter, *s*, and the upper surface of the eminences mentioned and the interpeduncular structures, that the general ventricular space is situated in the interior of the cerebrum. The upper part of this space is again divided by a median vertical partition, so as to form the two lateral ventricles: below this, it forms a single cavity, named the third or middle ventricle, which communicates with both the lateral ventricles above, and, below, with the ventricle of the cerebellum or fourth ventricle. The median vertical partition, which separates the lateral ventricles from each other, consists at one part (septum lucidum) of two layers, between which is contained the fifth and remaining ventricle of the brain.

The anatomy of these parts is conveniently studied by removing successive portions of the hemispheres by horizontal sections, beginning from above.

The first horizontal section, to be made about half an inch above the corpus callosum, displays the internal white matter of each hemisphere, speckled with red spots where its blood-vessels have been divided, and surrounded on all sides by the gray matter, which is seen to follow accurately the convoluted surface, and to be of nearly equal thickness at all points. This white central mass in each hemisphere was named by Vicq-d'Azyr the *lesser oval centre* (centrum ovale minus). On separating the remaining portions of the two hemispheres from each other, it is seen that they overlap the corpus callosum for some distance at each side. These projecting margins of the hemispheres, which are, in fact, part of the gyrus fornicatus, on each side, have been named *labia* cerebri, and the spaces covered in by them, the *ventricles of the corpus callosum*,—though these parts do not seem to need any special designation.

The hemispheres being in the next place sliced off down to the level of the corpus callosum, the white substance of that part is seen to be continuous with the internal medullary matter of both hemispheres: and the large white medullary mass thus displayed, surrounded by the border of cortical substance, constitutes what is generally described as the *centrum ovale* of Vieussens.

It may here be stated generally, that the gray matter of some of the convolutions in the posterior part of the brain, consists, as seen on a section, of an external darker and an internal light layer, fig. 333, *r*. This appearance is usually well marked on the inner or flat surface of the posterior lobe. Some authors (Baillärger, Remak, and Foville) describe several alternate white and gray layers in the cortical substance of many of the convolutions.

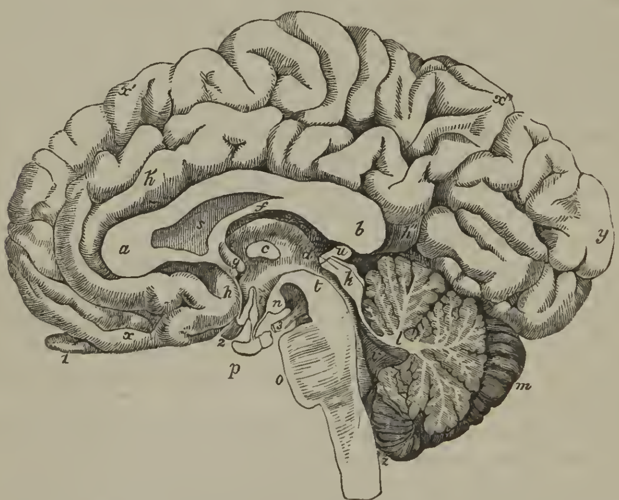
The *corpus callosum* (seen in section, fig. 332, *a*, *b*,) which is now supposed to be completely exposed above, also named the beam of the brain (trabs cerebri) and *great commissure*, is the cross portion of white substance which lies between the hemispheres at the bottom of the longitudinal fissure. It is three inches and upwards in length, and extends further forwards than backwards, reaching to about an inch

and a half of the anterior, and not quite two inches and a half of the posterior extremity of the cerebrum. It is about eight or ten lines in width behind, and somewhat narrower in front. Its thickness, which can only be seen on a vertical section, fig. 332, is greater at the ends than in the middle, and is greatest behind, where it amounts to three lines. In form it is somewhat arched from before backwards. Its upper surface, (partly seen at fig. 333, *d*,) is deeply marked by transverse fasciculi, which indicate the cross direction of the greater number of its fibres. Along the middle line is seen a line or mark, called the *raphe* or seam, which is bounded laterally by two white tracts, placed close to each other, named *striæ longitudinales*, or *nerves of Lancisi*. On each side, near the margin of the gyrus fornicatus, are seen other longitudinal lines (striæ longitud. laterales) which are occasioned by a few scanty white fibres having that direction. The arteries of the corpus callosum run along its upper surface, and the edge of the falx cerebri approaches closely to it behind, though not in front.

At the two sides, the corpus callosum is connected with the white substance of the hemispheres by an extension of its fibres into them.

In front it is reflected downwards and backwards, between the anterior lobes, towards the base of the brain, forming a bend named the

Fig. 332.



A vertical section in the median plane, of the cerebrum, cerebellum, pons, and medulla oblongata—the parts being all represented in their natural position. (After Sœmmerring.) *a*. Anterior, and *b*. Posterior extremity of corpus callosum, which is seen in section. *d, c, e*. Third ventricle. *c*. Soft commissure. *d, e*. Thalamus opticus, forming side of third ventricle. *f*. Fornix, united behind to corpus callosum. *b, g*. Anterior pillars of fornix. Between *g* and *h*, anterior commissure. Behind *h*, lamina cinerea. *h h' h''*. Convolution of corpus callosum or gyrus fornicatus. *i*. Infundibulum. *k*. Corpora quadrigemina, seen in section. *k* to *l*. Valve of Vieussens. *l*. Section of cerebellum, showing white and gray matter—appearance named arbor vitæ. *m*. Notch of cerebellum. *n*. Corpus albicans of right side. *o*. Pons Varolii (section). *p*. Pituitary body. *r*. Choroid plexus. *s*. Septum lucidum. *t*. Cerebral peduncle of right side in section. *u*. Pineal gland. *v*. Cavity of fourth ventricle. *d*. to *v*. Iter a tertio ad quartum ventriculum, or aqueduct of Sylvius. *x x' x''*. Marginal convolution of the longitudinal fissure. *y*. Posterior lobe of cerebrum. *z*. Opening leading into fourth ventricle. 1. Olfactory nerve. 2. Optic nerve divided through optic commissure. 3. Third nerve, or motor oculi.

knee (genu), *a*. The inferior or reflected portion, which is named the beak (rostrum), becomes gradually narrower as it descends (behind *h*). It is attached at each side to the anterior cerebral lobe, and is connected at its point by means of the lamina cinerea with the optic commissure. It also gives off the two bands of white substance, already noticed as the *peduncles* of the corpus callosum, which, diverging from one another, run backwards across the anterior perforated space on each side to the entrance of the Sylvian fissure.

Behind, the corpus callosum terminates in a free thickened border (*bourrelet*), the under surface of which is also free for a little distance forwards.

The under surface of the corpus callosum is connected behind with the fornix, *f*, a structure to be presently described, and in the rest of its length with the septum lucidum, *s*, the vertical partition between the lateral ventricles.

Although it presents a few longitudinal white fibres on its surface, the corpus callosum consists almost entirely of fibres having a transverse course towards each side, and spreading in all directions into the substance of the two hemispheres. Only the median portion of these fibres between the hemispheres is seen without dissection. As the transverse fibres from the anterior and posterior lobes of the cerebrum are necessarily aggregated in large numbers near the corresponding ends of the corpus callosum, its relative thickness at those points, in comparison with the rest of its extent, is accounted for; and since the posterior lobe reaches further beyond the corpus callosum than the anterior, the greater thickness behind is also explained.

By dividing the fibres of the corpus callosum in a longitudinal direction at a short distance on each side of the middle line, and about midway between the two ends of the hemispheres, an opening is made into the right and left *lateral ventricles* of the brain. These ventricles form part of the general ventricular space within the cerebrum; they are serous cavities, and are lined by a delicate epitheliated membrane, which is provided with cilia. In the natural state, their walls are moistened internally with a serous fluid, which sometimes exists in considerable quantity, even in a healthy brain.

Henlé states that the lining membrane of the ventricles consists of epithelium only, which lies immediately on the nervous matter. We have once observed an appearance unfavourable to this view. In the instance in question, the membrane over the surface of the corpora striata and adjacent parts was raised into small vesicular elevations by a clear fluid,—an appearance which was most probably due to a plexus of lymphatic vessels distended with lymph.

The part of the lateral ventricles which is laid open by the steps already indicated, is named the *centre* or *body;* from this point each ventricle is extended in three directions, forming so many prolongations named *horns* (cornua), which may be displayed by carefully slitting up and removing the white medullary substance of the hemisphere which covers them in. From the direction taken by these cornua, they are named the anterior, posterior, and middle or descending cornua; and the lateral ventricles themselves are named *ventriculi tricornes*. The *anterior cornu*, fig. 333, *g*, passes forwards and outwards in the substance of the anterior lobe; the *posterior cornu*, *h*,

backwards, outwards, and inwards in the posterior lobe; and the *descending cornu*, *q*, which traverses the middle lobe, passes at first backwards, outwards, and downwards, and then changing its course,

Fig. 333.

Section of cerebrum, displaying the lateral ventricles. On the right side the descending cornu is laid open. *a*, *b*. Parts of great longitudinal fissure. *c*. Section of front of corpus callosum. *d*. Part of posterior end of the same. *f*. The body of the fornix. *e*. The left choroid plexus. *g*. Anterior cornu, *h*, posterior, and *q*, descending cornu of the lateral ventricle. *k k*. Corpora striata. *l l*. Optic thalami. *n n*. Right and left hippocampus minor. *o*. Posterior pillar of fornix, becoming continued as the corpus fimbriatum *v*. *q*. Cornu ammonis, or Pes hippocampi. *r*. Shows alternate gray and white layers in cortical substance. *s s*. Right and left tænia semicircularis. *v*. Corpus fimbriatum. *y*. Eminentia collateralis.

runs forwards and inwards nearly to the point of the middle lobe. The posterior cornu, also named the *digital cavity*, is very variable in extent, even in the two sides of the same brain.

The parts forming the boundaries of the lateral ventricles, and those seen within them, may be first enumerated, and will afterwards be described in detail.

The *body* of this ventricle is covered in by the corpus callosum, which is therefore said to form its roof. On the inner side in the median plane is a vertical partition, the *septum lucidum*, fig. 332, *s*, which descends between the two lateral ventricles, from the under side of the corpus callosum, to the fornix. The *fornix*, *f*, itself, attached to the lower edge of the septum, is partly seen in the floor of this part of the ventricle. Appearing from below the outer margin of the fornix is seen a red vascular fringe, the *choroid plexus*, *e*, next to that a portion of the upper surface of the *thalamus opticus*, *l*. Beyond the thalamus is the *corpus striatum*, *k*, and between the two last-named parts, is a narrow tape-like band, *tænia semicircularis*, *r*. On the outer side of the corpus striatum we arrive again at the under surface of the corpus callosum.

The anterior cornu is also covered in by the corpus callosum; it turns round the anterior free extremity of the corpus striatum, descending as it proceeds, and is bounded behind by that body, and in front by the reflected part of the corpus callosum.

The middle or descending cornu turns round the back part of the optic thalamus which appears in its cavity, and forms its anterior boundary. It is covered in by the thalamus, and by the medullary substance of the middle lobe. The principal object seen upon its floor is a long curved eminence, which follows the direction of the cornu towards its anterior extremity, and is notched, or indented on its surface; this is the *hippocampus major*, *q*. Along the inner edge of this eminence is seen a narrow white band, named *corpus fimbriatum*, *v*, which is prolonged from the fornix; to the inner side of that is a part of the choroid plexus, *e*, and next to that the back of the optic thalamus.

The posterior cornu seems, as it were, scooped out of the substance of the posterior lobe. The choroid plexus does not enter it. On its floor is seen a longitudinal ridge, named *hippocampus minor*, or *ergot*, *n*; and at the junction of the posterior with the descending cornu, between the hippocampus major and minor, is a smooth eminence, which varies much in size, named *eminentia collateralis*, *y*.

The *septum lucidum*, is a thin translucent partition, (fig. 332, *s*,) placed between the two lateral ventricles. It extends vertically between the corpus callosum above, and the anterior part of the fornix below; and as the latter sinks down in front away from the corpus callosum, the septum is somewhat triangular in form, being deep before and narrow behind. The septum lucidum is attached above, in front, and for a certain space below, to the corpus callosum, fitting in, as it were, into its anterior reflected portion. Below and further back it is attached to the fornix.

This vertical septum is double, being composed of two perfectly distinct laminæ, having an interval between them, which contains fluid and is lined by an epitheliated membrane. This is the *fifth ventricle*, *ventricle of the septum*, or *Sylvian ventricle*. It may be laid open by cutting through the corpus callosum, and detaching it for a certain distance from the upper border of the septum, (as in fig. 333.) In the human embryo, and also in some animals, the cavity of this ventricle communicates with that of the third ventricle in front and below; but in the adult human brain it forms a separate and insulated cavity. Tarin described a small fissure in it between the pillars of the fornix; but this is unusual.* In disease it is often distended with fluid.

Each of the laminæ of the septum which form the sides of the fifth ventricle, consists of an internal layer of white substance and an external layer of gray matter.

[The white fibres of the septum lucidum originate from the anterior lobe of the cerebrum and the gray matter covering the external surface of the septum, and belong to the class of antero-posterior commissures of the cerebrum. They may be afterwards traced into the fornix, giving the latter, indeed, a considerable accession.—J. L.]

* [A deep depression exists there, but does not communicate with the ventricle.—J. L.]

The *fornix* is a white longitudinal band, extending along the lower edge of the septum lucidum, and attached behind to the under surface of the corpus callosum. It appears in the floor of both lateral ventricles, fig. 333, *f*, *o*, and dips downwards at each extremity, fig. 332, *f*, but rises in the middle so as to form a sort of vault or arch (fornix), which is free on its under surface. It may be described as consisting of two lateral halves, which are separated from each other in front and behind, but between those points are joined together in the median plane. The two parts in front form the anterior pillars of the fornix; the middle conjoined part is named the body; and the hind parts, which are again separated from each other, form the posterior pillars.

The *body* of the fornix, fig. 333, *f*, is triangular in shape, being broad and flattened behind, where it is connected with the under surface of the corpus callosum, and narrower in front as it dips down to leave that body,—the space between them being filled up by the septum lucidum. Its lateral edges are in contact with the choroid plexuses, and its under surface rests upon a membrane, which connects those two plexuses together (velum interpositum).

The *anterior crura* or *pillars* of the fornix, figs. 335, 336, *f*, consisting entirely of white fibres, descend slightly apart from each other through a quantity of gray matter on the sides of the third ventricle, fig. 345, *t'*, as far as the corpora albicantia, *n*, where they turn up and enter the substance of the corresponding optic thalamus, *. The external or white portion of each of the corpora albicantia is composed of the fibres of the corresponding pillar of the fornix, which there forms a twisted loop. These pillars might therefore be described as commencing in the substance of the thalami, descending into the corpora albicantia, in which they are twisted in the manner described, then rising up through the gray matter on the sides of the third ventricle, becoming free above, and at length joining together to form the body of the fornix. They are connected with the peduncles of the pineal gland, and with the tænia semicircularis, as will be afterwards described.

Immediately behind the anterior pillars of the fornix, a small opening is seen on either side. The two openings pass downwards and backwards towards the middle line, and meeting below, lead into the upper part of the third ventricle. The passage thus formed is the *foramen of Monro*. It is single below, where it communicates with the third ventricle, but divides above, somewhat like the letter Y, into two branches, one to each lateral ventricle. In this way it will be seen that all three ventricles communicate with each other at this point.

The two flat bands into which the fornix divides behind are its *posterior pillars* or *crura*, fig. 333, *o*. Adhering at first to the under surface of the corpus callosum, they pass backwards diverging from each other; and then leaving the corpus callosum, turn suddenly downwards into the descending cornu of the corresponding lateral ventricle, where we shall presently follow them. On dividing the fornix across in front, and turning it back with the corpus callosum, so as to expose the under surface, a triangular portion of the latter, fig. 335, *e*, is seen between the diverging posterior crura of the fornix, marked with lines,

some of which are transverse, but others longitudinal or oblique. To this part the term *lyra* has been applied.*

In the posterior cornu of the lateral ventricle, we have to examine the *hippocampus minor*, fig. 333, *n*, also called the *ergot* or *calcar avis*, from its resemblance to a cock's spur. It is a white eminence pointed at its posterior extremity, forming a relief along the inner side of the cornu: beneath the white surface it consists of gray matter, which is part of the cortical substance of the hemispheres, corresponding with the bottom of a sulcus seen on the inner surface of the posterior lobe.

The *hippocampus major* (pes hippocampi; or cornu ammonis, from its resemblance to a ram's horn) is a large white eminence, *q*, already mentioned as lying along the floor of the descending cornu of the lateral ventricle. Behind the pes, and between it and the hippocampus minor, is another white eminence, known as the *eminentia collateralis, pes accessorius*, *y*, which has a similar relation to a convolution as the lesser hippocampus, and is often as large as, or larger than that elevation. The hippocampus major becomes enlarged towards its anterior and lower extremity, and is indented or notched on its edge, so as to present some resemblance to the paw of an animal, whence, no doubt, its name of pes hippocampi.

The external white substance of the hippocampus major is partly derived from the posterior pillar of the fornix, which, as already stated, enters the descending cornu of the lateral ventricle. The remaining part of that pillar forms a white band, like a tape, which is attached along the inner border of the great hippocampus, and forms the *tænia hippocampi*, or *corpus fimbriatum*, *v*. It reaches down to the end of the pes, but its further connexions are not well known.

Fig. 334.

Section of the hippocampus major, to show the arrangement of its gray and white substance. *a*. White layer on its surface. *b*. Gray substance which becomes rolled up. *d*. White reticulated substance, on the surface of gyrus fornicatus. *c*. Fascia dentata. *e*. Cavity of lateral ventricle.

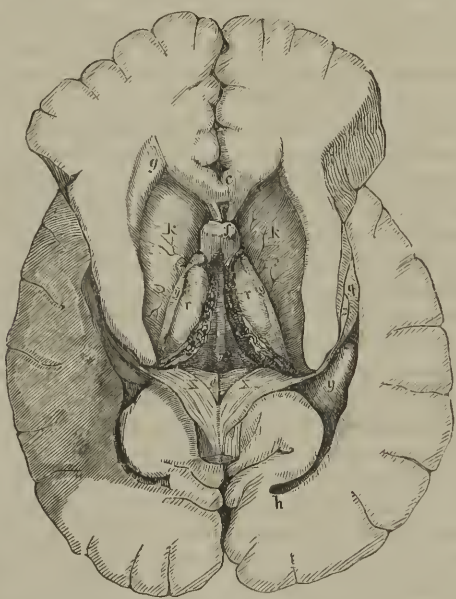
Along the inner border of the corpus fimbriatum, (which is a continuation of the posterior pillar of the fornix,) and between it and the thalamus, is the prolongation of the choroid plexus, *e*, occupying in this situation a part of the transverse fissure, to be presently described. On separating the corpus fimbriatum from the plexus, and raising the edge of the former, we discover a gray indented ridge, which runs parallel with it, but which, strictly speaking, is situated outside the cavity of the cornu. This is the *fascia dentata*, fig. 334, *c*.

The structure of the pes hippocampi is best examined by making a cross section through it. It will then be seen

* The varying direction of these lines has been represented by Vicq-d'Azyr, who attributes them to the impression of the vessels of the subjacent velum interpositum. The term *corpus psalloides* given by the early anatomists to the fornix, in consequence of its resemblance to an arch (ψαλλιδοειδὴς—Galen; from ψαλὶς or ψαλλὶς, fornix, an arch), was erroneously interpreted by Winslow and others, who supposed that it meant something which had the appearance of a harp or similar stringed instrument, and that it was intended specially to designate the part marked with the linear impressions described, which accordingly was named *lyra* and *psalterium*.

that its surface is composed of white substance, fig. 334, *a*, which is continuous with that of the corpus fimbriatum. Within, it contains a stratum of gray matter, *b*, doubled on itself, and continued from the cortical substance on the adjacent convolution of the middle lobe (part of the gyrus fornicatus). This gray layer accompanied by the thin coating of white matter, *d*, already described in this situation as the reticulated white substance (see p. 205), is first bent inwards, and then curls outwards upon itself, so as to terminate by a free indented edge, which appears at the surface as the fascia dentata, *c*.

Fig. 335.



A section of the cerebral hemispheres, showing both lateral ventricles, after the fornix has been divided and turned back, to expose the velum interpositum. *c.* The anterior portion of corpus callosum, cut across. *e.* The lyra, or under surface of back of corpus callosum. *f.* Anterior pillars of fornix cut across. N. B. These are represented of too great size. *g.* Anterior, *h*, posterior cornu of lateral ventricle. *k k.* Corpora striata. *q.* Pes hippocampi. *r r.* Thalami optici. *s s.* Tænia semicircularis. *t t.* Choroid plexuses. *v.* Velum interpositum. *x x.* Posterior pillars of fornix. *y.* Eminentia collateralis.

From what has preceded, it will have been understood that the fornix is applied in nearly its whole length to the optic thalamus of each side—the body of the fornix, fig. 333, *f*, resting on the upper surface of the thalamus, *l*, and each posterior pillar being applied to the posterior surface of that body in the descending cornu. On separating these two parts it will be seen that a fissure exists between them. This is named the *transverse fissure of the cerebrum.* Through it the pia mater, from the exterior of the brain, passes into the ventricles to form the choroid plexuses. This fissure runs downwards and forwards into each descending cornu; it therefore extends from the point of the descending cornu of one side to that of the other, reaching as far for-

wards as the foramen of Monro, its extent corresponding exactly with that of the choroid plexuses. It is closed on the inner side by the lining membrane of the lateral ventricle, which is said to pass from the fornix to the thalamus over the choroid plexus.

On raising up the fornix, it will be seen that it rests on a vascular membrane which is interposed between it and the parts beneath. This is named the *velum interpositum* or *tela choroidea*, fig. 335, *v*. It connects the choroid plexuses of the two sides together, and like them is a prolongation of the pia mater. This last-named membrane passes from the outer surface of the brain underneath the corpus callosum and fornix, and above the corpora quadrigemina, the pineal gland and the thalami, through the transverse fissure into the lateral ventricle. The membranous prolongation thus formed, is of a triangular shape: the middle part of it is covered by the fornix, and constitutes the velum interpositum, whilst the remainder projects at each side of the fornix into the lateral ventricles, and forms by its free borders the right and left choroid plexuses.

The *choroid plexuses*, fig. 333, &c., *e e*, appear like two red knotted fringes, reaching from the foramen of Monro to the point of each descending cornu. They are represented as being covered by a reflection of the lining membrane of the ventricle, which in this way is considered to keep the choroid plexuses outside the serous cavity of the ventricle, just as the intestines are excluded from the cavity of the peritoneum; but in admitting this view, it must be remembered that the epithelium changes its character where it covers the plexuses.

At the foramen of Monro, where the middle and lateral ventricles communicate, their lining membrane is continuous, and here the two choroid plexuses are connected with one another.

On raising the velum interpositum, two slight vascular fringes are seen running along its under surface, and diverging from each other behind. They form the *choroid plexuses* of the third ventricle.

The choroid plexuses consist of a highly vascular villous membrane. The villi with which they are covered are again divided upon their surfaces and at their borders into smaller processes, along which fine vessels are seen to run. They are covered by a single layer of thick epithelium composed of large roundish corpuscles, in each of which is seen, besides a distinct nucleus, a small bright yellow spot. The arteries of the velum interpositum and choroid plexuses enter from behind beneath the corpus callosum, and also at the point of the descending cornu: after ramifying in the plexuses, they send branches beneath the ventricular lining membrane to enter the substance of the brain. Veins issuing from the cerebral substance are seen on the surface of the ventricles, and for the most part join the veins of the choroid plexuses. The greater number of these terminate in two principal vessels, named the veins of Galen, which run backwards on the velum interpositum, and passing out beneath the corpus callosum pour their blood into the straight sinus, having generally first united into a single trunk.

The velum having next been removed, the optic thalami are brought fully into view, and the cavity of the third ventricle, situated between

them. In front and to the outer side of the thalami, as already stated, are the *corpora striata.* These last are two large ovoid masses of gray matter, fig. 333, &c., *k k*, the greater part of which is embedded in the middle of the white substance of the hemisphere of the brain, whilst a part projects into the fore part of the body and the anterior cornu of the lateral ventricle. This *intraventricular portion* of the corpus striatum, *k k*, figs. 335, 336, is of a pyriform shape, its larger end being turned forwards, and its narrow end being directed outwards and backwards, so that the optic thalami of the two sides are received between the diverging corpora striata. The surface of the corpus striatum is composed of gray matter; it is covered by the lining membrane of the ventricle, and is crossed by veins of considerable size. At some depth from the surface, white fibres may be seen on cutting into it, which are prolonged from the corresponding cerebral peduncle, and give it the streaked appearance from which it has received its name.

The *extraventricular* portion of the corpora striata will be afterwards described.

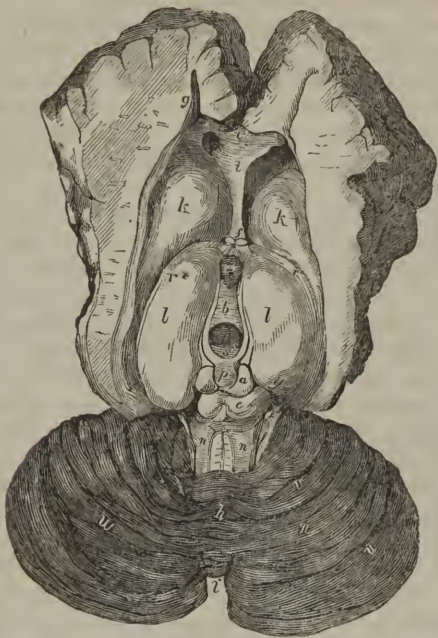
Along the inner border of each corpus striatum, and in a depression between it and the optic thalamus, is seen a narrow, whitish, semitransparent band, named *tænia semicircularis,* fig. 333, &c., *s s*, which continues backwards into the descending cornu of the ventricle, where its connexions cannot be assigned with precision. In front it reaches the corresponding anterior pillar of the fornix, and descends in connexion with that cord of white substance. It is more transparent and firm on the surface, especially at its fore part: and this superficial stratum has been named *stria cornea.* The tænia consists of longitudinal white fibres, the deepest of which running between the corpus striatum and the thalamus, were named by Vieussens *centrum geminum semicirculare.* Beneath it are one or two large veins, which receive those upon the surface of the corpus striatum, and end in the veins of the choroid plexuses.

The *thalami optici*, figs. 333 to 336, *l l*, (posterior ganglia of the brain,) are of an oval shape, and rest on the corresponding cerebral crura, which they in a manner embrace. On the outer side each thalamus is bounded by the corpus striatum and tænia semicircularis, and is then continuous with the medullary substance of the hemisphere. Its upper surface is free and prominent and is partly seen in the lateral ventricle, *k*, and partly covered by the fornix. The posterior surface, which is also free, projects into the descending cornu of the lateral ventricle. The inner sides of the two thalami are turned towards each other, and form the lateral boundaries of the third ventricle, across which, however, they are connected by a gray mass of nervous substance, named the soft commissure. Near the fore part of each thalamus is a small elevation on its upper surface, named its *anterior tubercle*, fig. 336, *. The optic thalami are white on the surface, and consist of several layers of white fibres intermixed with gray matter.

The third ventricle, fig. 336, *z* to *s*, is a narrow longitudinal fissure or cleft placed between the optic thalami, which bound it on its two

sides. It is covered above by the velum interpositum and the fornix. Beneath, its floor is formed by the following parts, which have been already described, as seen on the base of the cerebrum, viz., commencing from behind, the posterior perforated space, the corpora albicantia, the tuber cinereum and infundibulum, and the lamina cinerea, which also serves to close it in front, as high as the anterior commissure. Passing across the cavity of the third ventricle are seen

Fig. 336.



Section of the cerebrum, displaying the surfaces of the corpora striata, and optic thalami, the cavity of the third ventricle, and the upper surface of the cerebellum.—*a e.* Corpora quadrigemina,—*a* testis, *e* nates. *b.* Soft commissure. *c.* Corpus callosum. *f.* Anterior pillars of fornix. *g.* Anterior cornu of lateral ventricle. *k k.* Corpora striata. *l l.* Optic thalami. * Anterior tubercle of the left thalamus. *z* to *s.* Third ventricle. In front of *z*, anterior commissure. *b.* Soft commissure. *s.* Posterior commissure. *p.* Pineal gland with its peduncles. *n n.* Processus a cerebello ad testes. *m m.* Hemispheres of the cerebellum. *h.* Superior vermiform process. *i.* Notch behind the cerebellum.

three commissures, named from their position, anterior, middle, and posterior.

The *middle* or *soft commissure, b,* (com. mollis,) is composed almost entirely of gray matter, and connects the two thalami. It is sometimes, though very rarely, wanting; but it is more frequently torn across in examining the brain.

The *anterior* commissure, in front of *z*, is a round bundle of white fibres, placed immediately in front of the anterior pillars of the fornix, and crosses between the corpora striata. It marks the anterior boundary of the ventricle; its fibres extend laterally through the corpora striata, a long distance into the substance of the cerebral hemispheres.

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The *posterior commissure*, *s*, also white, is placed across the back part of the ventricle, immediately before and below the pineal gland. It is smaller than the anterior commissure, and has the form of a flattened band. It passes into the thalami on each side, but does not extend so far into the substance of the brain as the anterior commissure.

The following apertures lead from or into the third ventricle:

Above and before is the foramen of Monro, by which the third communicates with the two lateral ventricles.

Behind, is an opening leading into the *iter a tertio ad quartum ventriculum*, or *aqueduct of Sylvius*, fig. 332, *d*, *v*, which passing down below the posterior commissure, and the corpora quadrigemina, conducts into the fourth ventricle.

In the floor of the third ventricle is a deep pit, corresponding with the infundibulum, and generally named *iter ad infundibulum*, but there is no outlet at this part.

The lining membrane of the lateral ventricles is continued down through the foramen of Monro, and lines the third ventricle, whence it extends along the Sylvian aqueduct into the fourth ventricle. Bichat conceived that this membrane was continuous with the arachnoid membrane on the exterior of the brain, and he therefore named it the internal arachnoid. He supposed that the external arachnoid membrane entered the third ventricle in the form of a tubular process, which passed beneath the posterior end of the corpus callosum and fornix, above the pineal gland and through the velum interpositum, and thus opened into the upper and back part of the third ventricle. The existence of this canal, named the *canal of Bichat*, is doubtful. It is certainly not constant.

Pineal gland and *corpora quadrigemina.*—Behind the third ventricle, and in front of the cerebellum, are certain eminences, which may be reached from the surface of the brain. These are the corpora quadrigemina, and above them is the pineal gland.

The *pineal gland*, fig. 332, *u*, fig. 336, *p*. (conarium,) so named from its shape (pinus, conus, the fruit of the fir,) is a small reddish body, which is placed beneath the back part of the corpus callosum, and rests upon the anterior pair of the corpora quadrigemina. It is very firmly attached to the under surface of the velum interpositum, so that it is liable to be torn away from the brain in removing that membrane. It is about three lines in length, and its broad part or base is turned forwards, and is connected with the rest of the cerebrum by white substance. This white substance is principally collected into two small rounded bundles, named *peduncles* of the pineal gland, which pass forwards upon the optic thalami, to which they are attached along the upper limit of the third ventricle, and may be traced in that direction as far as the anterior pillars of the fornix, in conjunction with which they descend, fig. 336. These peduncles are connected with each other behind. The base of the pineal gland is also connected by a transverse lamella of white substance with the back of the posterior commissure. Some anatomists have described

two *inferior peduncles*, which descend upon the inner surface of the thalami.

The pineal gland is very vascular. It is hollowed out into two or more cells, which, sometimes at least, open anteriorly into the ventricle, and almost always contain, besides a viscid fluid, a quantity of gritty matter, named *acervulus cerebri.* This consists of microscopic round particles, aggregated into small compound masses, which are again collected into larger groups. It is composed of earthy salts combined with animal matter; viz., phosphate and carbonate of lime, with a little phosphate of magnesia and ammonia (Stromeyer). It is found at all ages, frequently in young children, and sometimes even in the fœtus. It cannot, therefore, be regarded as the product of disease. This sabulous matter is frequently found on the outside of the pineal body, or even deposited upon its peduncles.

The *corpora* or *tubercula quadrigemina* are four rounded eminences, fig. 336, *a e*, separated by a crucial depression, placed two on each side of the middle line, one before another. They are connected with the back of the optic thalami, and with the cerebral peduncles at either side; and they are placed above the passage leading from the third to the fourth ventricle.

The upper or anterior tubercles, fig. 330, *a a*, are somewhat larger and darker in colour than the posterior, *b b*. In the adult, both pairs are solid, and are composed of white substance outside containing gray matter within.

They receive bands of white fibres from below, the chief of which are derived from a fasciculus named the fillet. A white cord also passes up on each side from the cerebellum to the corpora quadrigemina, and is continued onwards to the thalami: these two white cords are the *processus a cerebello ad testes*, or superior peduncle of the cerebellum, fig. 330, *f*, fig. 336, *n n*. At each side, the corpora quadrigemina send off two white tracts, which pass to the thalami and to the commencements of the optic nerves. These tracts are prominent on the surface, and are sometimes named *brachia.*

In the human brain these quadrigeminal bodies are small in comparison with their size in the series of animals. In ruminant, soliped, and rodent animals, the anterior tubercles are much larger than the posterior, as may be seen in the sheep, horse, and rabbit; and hence have been applied the names *nates* to the anterior and *testes* to the posterior tubercles. In the brains of carnivora, the posterior tubercles are rather the larger.

In the fœtus, this part of the brain appears very early, and then forms a large proportion of the cerebral mass. The eminences are at first single on each side and hollow. They are constant in the brains of all vertebrate animals, but in fishes, reptiles, and birds, they are only two in number, and hollow: in marsupialia and monotremata, they are also two in number, but are solid.

To the outer side of the corpora quadrigemina, and on the under and back part of each optic thalamus, are found two small oblong and flattened eminences, connected with the posterior extremity of the optic tract. These optic tracts, which we have already seen on the base of

the cerebrum, attached to and embracing the under side of the corresponding peduncles, may be traced back to the thalami. Each tract becomes flattened and broader as it approaches the thalamus, and makes a bend as it turns round the peduncle to reach the back part of that body. Near this bend, which is named the *knee* (genu), are placed the two small eminences just spoken of. They are two little masses of gray matter, about the size and shape of coffee-beans, placed one on the outer and one on the inner side of the genu of the optic tract, and hence are named respectively *corpus geniculatum, externum* and *internum.* They send fibres into the optic tract, and also into the thalamus of the same side.

The fibres of these tracts are therefore derived from three sources, viz., the thalamus, the tubercula quadrigemina, and the corpora geniculata.

Extending downwards and somewhat outwards from the corpora quadrigemina to the fore part of the cerebellum, and connecting the latter with the cerebrum, are two large white cords, the *processus a cerebello ad testes*, fig. 336, *n*, *n*, already alluded to. Between them is stretched a thin semi-transparent layer of nervous matter, which lies over the passage from the third to the fourth ventricle, and, lower down, covers in a part of the fourth ventricle itself. This is the *valve* of Vieussens, between *n n* (velum medullare anterius). It is narrow above, where it is connected with the quadrigeminal bodies, and broader below, where it is continuous with the median portion of the cerebellum. From its attachment at the sides to the processus ad testes, these latter have been described as the *pillars* of the valve.

The upper portion of the valve is composed of medullary substance, but a few transverse ridges of gray matter extend upon its lower half, as if they were prolonged from the gray lamellæ of the cerebellum, with which it is there continuous. From between the posterior quadrigeminal tubercles a slight median ridge, name *frænulum*, descends a little way upon the velum ; and on each side of this the commencing transverse fibres of the fourth pair or pathetic nerves may be seen.

The valve of Vieussens is overlapped and concealed by the adjacent folia of the cerebellum, which must be drawn back in order to bring it into view.

THE CEREBELLUM.

The *cerebellum, little brain*, or *after brain*, consists of a *body* and three pairs of *crura* or *peduncles*, by which it is connected with the rest of the encephalon. They are named superior, middle, and inferior peduncles, and have all been incidentally mentioned.

The *superior peduncles* connect the cerebellum with the cerebrum (crura ad cerebrum). They are the parts already described under the name of the processus ad testes.

The *inferior peduncles* (processus a cerebello ad medullam; crura ad medullam) pass downwards to the back part of the medulla oblongata, and correspond with the restiform bodies.

The *middle peduncles* (crura ad pontem) pass from the middle of the cerebellum around the outer side of the crura of the cerebrum, and

meet in front in the pons Varolii, constituting its transverse fibres. They connect the two halves of the cerebellum together below.

All these peduncles consist of white fibres only; and they pass into the interior of the cerebellum at its fore part. Their connexions within that organ will be afterwards described.

The *body* of the cerebellum being covered with cortical substance, is of a gray colour externally, but is rather darker on the surface than the cerebrum. Its greatest diameter is transverse; it is about three and a half or four inches wide, about two or two and a half from before backwards, and about two inches deep in the thickest part, but is much thinner all around its outer border.

It consists of two lateral *hemispheres* joined together by a median portion called the *worm*, or vermiform process, which in birds and in some animals still lower in the scale is the only part existing.

The hemispheres are separated behind by a deep *notch*, figs. 336, 337, *i*, so that the outline of the two, as seen from above, resembles a very wide-shaped heart as drawn on playing cards, the notch being directed backwards. On the upper surface, the median portion or superior vermiform process, fig. 336, *h*, though slightly elevated, is scarcely marked off from the hemispheres, so that the general surface of the organ, which is here inclined on either side, is uninterrupted. Below, the hemispheres are convex and are separated by a deep fossa, named the *valley*, fig. 337, *i* to *s* (vallecula), which is continuous with the notch behind. Into this hollow the medulla oblongata, *m*, is received in front, and the falx cerebelli behind. The under surface of the median portion of the cerebellum appears in this depression, and is sometimes named the inferior vermiform process.

Fig. 337.

An under view of the cerebellum, seen from behind, —the medulla oblongata, *m*, having been cut off a short way below the pons. (Reil.) *c.* Pons Varolii. *d.* Middle crus of cerebellum. *e. e.* Crura cerebri. *i.* Notch on posterior border. *k.* Commencement of horizontal fissure. *l.* Flocculus or subpeduncular lobe. *m.* Medulla oblongata cut through. *q* to *s.* The inferior vermiform process, lying in the vallecula. *p.* Pyramid. *r.* Uvula. *n. n.* Amygdalæ. *s.* Nodule or laminated tubercle. *x.* Posterior velum, partly seen. *w.* Right and left hemispheres of cerebellum. 3 to 7. Nerves. 3. 3. Motores oculorum. 5. Trigeminal. 6. Abducent nerve. 7. Facial and auditory nerves.

The body of the cerebellum at the surface, and for some depth, consists of numerous nearly parallel laminæ or folia, which are composed of gray and white matter, and might be compared with the gyri of the cerebrum, but are smaller and not convoluted. These are separated by sulci of different depths.

One principal fissure or sulcus, named the *great horizontal fissure*, divides the cerebellum into an upper and a lower portion. It begins in front at the entrance of the middle crura, and passes horizontally backwards around the outer border of the hemispheres. From this primary fissure numerous others proceed on

both the upper and under surface, forming parallel curves, having their concavities turned forwards and separating the folia from each other. All these furrows do not go entirely round the hemisphere, for they often coalesce with one another; and some of the smaller furrows have even an oblique course between the others. Moreover, on opening the larger fissures, many of the folia are seen to lie concealed within them, and do not reach the surface of the cerebellum.

Certain fissures, which are deeper than the rest and constant in their position, have been described as separating the cerebellum into lobes, which are thus named:—

The *central lobe*, fig. 336, *v*, situated on the upper surface, consists of about eight folia, immediately adjoining the anterior concave border. The *superior* and *anterior* lobe, *m*, and the *superior* and *posterior* lobe, *u*, are placed between the central lobe and the great horizontal fissure. On the under surface, fig. 337, *m*, are seen successively the *inferior posterior* lobe, the *slender* lobe, the *biventral* lobe, the *amygdalæ*, *n*, *n*, and the *subpeduncular lobe* or *flocculus*. This last-named lobule, *l*, *l*, *lobule of the pneumogastric nerve* (Vicq-d'Azyr), *subpeduncular lobe* (Gordon), or *flocculus*, projects behind and below the middle peduncle of the cerebellum. It is connected by a slender pedicle of white fibres to the rest of the hemisphere; but its exposed surface is gray, and is subdivided into a few small laminæ.

Within the vallecula, or on its borders, the following parts are seen.

Commencing from behind, a conical and laminated projection, named the *pyramid*, is first met with, *p*. In front of that is another smaller projection, called the *uvula*, *r*, which is placed between the two rounded lobes at the sides of the vallecula, named the *amygdalæ*, *n n:* these terms being suggested by a comparison with the parts so named in the throat. Between the uvula and amygdalæ on each side, but concealed from view, is extended a ridge of gray matter, indented on the surface, and named the *furrowed band*. Still further forward is the anterior pointed termination of the inferior vermiform process, named the *nodule*, *s*, which projects into the fourth ventricle, and has been named the *laminated tubercle* (Malacarne). On each side of the nodule is a thin white lamella of a semilunar form, which is attached by its posterior convex border, and is free and concave in front. The outer ends of these lamellæ are attached to the flocculi, and the inner ends to the nodule, and to each other in front of that projection. The two lamellæ together constitute the *posterior medullary velum*, *x*, (velum medul. post.), which has been compared to the valve of Vieussens, —the one being attached to the superior extremity and the other to the inferior extremity of the middle or vermiform portion of the cerebellum. This posterior velum is covered in and concealed by the amygdalæ, and cannot be properly seen until those lobules have been turned aside.

The Fourth Ventricle.—The space left between the medulla oblongata in front and the cerebellum behind, is named the fourth ventricle, or *ventricle of the cerebellum*, fig 332, *v*.

The cavity of this ventricle is contracted above and below, and is

widest across its middle part. The anterior extremity of the inferior vermiform process projects into it from behind, and higher up it is covered by the Vieussenian valve. It is bounded laterally by the superior peduncles, and lower down it is shut in at the sides by the reflection of its lining membrane from the medulla to the cerebellum. The upper end of the ventricle is continuous with the Sylvian aqueduct or passage (iter) leading up to the third ventricle.

The anterior boundary or *floor* of the fourth ventricle, fig. 330, *v* 7, *v'* 7, is formed by the back of the medulla oblongata and pons Varolii. It is shaped like a lozenge, truncated at its upper part. Below, it is bounded by the diverging posterior pyramids and restiform bodies, surmounted along their margin by a band of nervous substance called the *ligula.* In the middle of the floor is seen the longitudinal median fissure, *v v'*, which is gradually obliterated towards the upper part of the ventricle, and forms at its lower end, where it meets the converging borders of the posterior pyramids, the point of the *calamus scriptorius*, *v'*. Near this is the small orifice already described as leading into the remnant of the canal in the spinal cord.

Along the sides of the median fissure, in the upper part of the ventricle, are placed two rounded longitudinal eminences, grayish below, but appearing white higher up, fig. 330. These are the *fasciculi teretes*, fig. 343, *a*, (faisceaux innominés,—Cruveilhier,) which pass up from the medulla along the back of the pons and enter the cerebrum.

Towards the lower part of the ventricle, the central gray matter of the medulla is opened out on the surface, being covered only by a thin translucent layer, and forms several small angular elevations, fig. 330, *e*, *c*, *i*, *v'*, which, as we shall hereafter see, have been recently shown to be connected with the origin of the eighth, ninth, and probably the fifth pair of nerves. The gray matter in the floor of the fourth ventricle has been named *fasciolæ cinereæ.* Upon it, several transverse white lines or striæ are usually observed, passing across from the median fissure, around the sides of the restiform bodies. Some of these white striæ form part of the roots of the auditory nerves, [7], [7], a few run slantingly upwards and outwards on the floor of the ventricle, whilst others again embrace the corresponding half of the medulla oblongata. These transverse lines are sometimes wanting, in which case the white fibres on which they depend probably exist at some depth beneath the surface,

The *lining membrane* of the ventricle is continuous with that of the other ventricles through the aqueduct of Sylvius, in which situation it is marked by delicate rugæ, oblique or longitudinal in direction. At the sides it is reflected from the medulla to the cerebellum, as already stated, and extends for a considerable distance outwards between the flocculus and the seventh and eighth nerves. At the lower end of the ventricle, this cavity communicates with the subarachnoid space. This communication, as stated by Magendie, may be generally shown independently of laceration. Bichat describes the lower end of the fourth ventricle as being closed by the lining membrane, a condition which may perhaps sometimes exist.

Projecting into the fourth ventricle at each side, and passing from

the point of the inferior vermiform process outwards and upwards to the outer border of the restiform bodies, are two small vascular processes, which have been named the *choroid plexuses* of the fourth ventricle.

Section of the cerebellum.—Sections of this part, in any or in all directions, show that the surface of the hemispheres and vermis, even at the bottom of the smallest furrows, is composed of a continuous layer of gray matter; and that the white medullary substance is accumulated in the centre, but sends off numerous thin and flat processes, which pass into the middle of each gray lamina. Owing to this arrangement, sections of the cerebellum present a beautifully foliated or arborescent appearance, which however is most perfectly seen on a vertical section made in the median plane, where the relative quantity of the central white matter is small. The appearance in question has been named *arbor vitæ*, fig. 332, *l*.

In the lateral hemispheres where the peduncles enter, the white matter is more abundant; and if a section be made through either hemisphere half way between its centre and the middle of the vermiform process, it will display a nucleus of gray matter, which is named the *corpus dentatum* of the cerebellum, fig. 338, *b*. This presents the appearance of a waved line of yellowish-brown matter, surrounded by white substance and containing whitish matter within. This line is interrupted at its upper and inner part. In whatever direction the section is carried through the corpus dentatum, this waved line is seen, so that the dentate body may be described as consisting of a plicated pouch or capsule of gray substance, open at one part and inclosing white matter in its interior, like the corpus dentatum of the olivary body. White fibres may be traced out from it to the superior peduncles of the cerebellum and to the valve of Vieussens.

INTERNAL STRUCTURE OF THE CEREBRO-SPINAL AXIS.

The brain and spinal cord consist of *gray* and *white* nervous matter; the former being also called the *cineritious*, or where it lies upon the surface the *cortical* substance, and the latter being also named *medullary*. The microscopic structure of these two components of the nervous centres is given in the part devoted to the general anatomy.

Of the white or medullary substance, it may here be stated, that it consists of microscopic fibres arranged into laminæ and bundles, between which intervening vessels ramify. The existence, course, and arrangement of these fibrous plates and bundles, which are rendered much more evident by hardening the brain in alcohol, are found to be constant in all cases; but our knowledge of their apparently complicated connexions with each other and with the gray matter, is at present imperfect and fragmentary; for which reason, the subject can only be briefly treated of consistently with the limits and purposes of the present work. For more detailed information the reader is referred to the special treatises enumerated below.*

* Vicq-d'Azyr—Traité de l'Anat. et Physiol., 1786; Reil—Various Memoirs in his Archiv. für die Physiologie; Rolando—Sopra la vera struttura del Cervello, 1828; Mayo—Engravings of Structure of Brain and Spinal Cord, 1827; Solly—The Human Brain, &c.,

INTERNAL STRUCTURE OF THE SPINAL CORD.

The general arrangement of the white and gray substances in the spinal cord may be here briefly recapitulated.

The white matter in each half of the cord, is divided by the fissures or by the gray matter within into three columns, fig. 326, an anterior, *a e c*, lateral, *c e b*, and posterior, *b e p*. The anterior lateral columns are continuous with each other at the surface, there being no antero-lateral fissure, and form in fact but a single column—the antero-lateral column *a e b*. The posterior columns include also the two small tracts placed one on each side of the posterior median fissure, sometimes named the slender fasciculi (see p. 193). The substance of all these columns is penetrated at intervals by blood-vessels, which are supported on fine membranous processes, and in this way it is broken up into separate compressed bundles or into lamellæ having a radiated arrangement. The white matter of the two halves of the cord is continuous before and behind the central gray substance by means of the anterior and posterior white commissures. Lastly, it may be mentioned that the white substance of the cord consists of tubular nervous fibres, having for the most part a longitudinal course.

The *gray* matter, as seen on a section, forms two crescent-shaped masses, turned back to back and joined across the median plane by the gray commissure, figs. 326, 327. The small posterior cornu or horn of each crescent reaches the surface at the posterior lateral fissure. The anterior horn is larger and does not quite reach the surface of the cord. The gray matter of the posterior horn, *substantia gelatinosa*, has a peculiar microscopic structure, for it contains no ganglionic corpuscles; such bodies, however, are found in the anterior cornu, the gray matter of which was named by Rolando *substantia spongiosa*.

Origin of the spinal nerves.—The anterior and posterior roots of the spinal nerves are attached along the sides of the cord, opposite to the corresponding cornua of the gray matter, fig. 326,—the posterior roots, *s*, in a perfectly straight line, and the anterior roots, *r*, scattered somewhat irregularly upon the surface. It may be right here to remark that the anterior roots contain the motor, and the posterior roots the sensory filaments in each nerve.

As to the *deep* connexions of these roots, it has long been supposed that part at least of their fibres entered into or passed out of the gray matter. In regard to the posterior roots, this is easily demonstrated, for the white fibres pass at once into the tip of the posterior horn of gray matter, in the posterior lateral fissure. The anterior roots have been said to reach the anterior gray cornu, by passing through the superficial stratum of white substance over it; but actual demonstration of the fact is yet wanted.

Both the anterior and posterior roots are undoubtedly connected

1836; Cruveilhier,—Anatomie Descriptive, 1835; Arnold—Bemerkungen über den Bau des Hirns, &c., 1838—and Icones Anatomicæ, Fasc. I.; Foville—Traité de l'Anat., &c. du Système Nerveux Cerebro-Spinal, avec planches, 1844; Förg—Vom innern Baue des Gehirns, 1844.

with the white matter of the cord ; but there is considerable difference of opinion as to the precise manner in which this connexion takes place.

According to one view (Grainger*), both roots are in part connected to the gray matter, and in part to the lateral column only of the white substance. Now, in regard to the anterior roots, from the scattered manner in which they arise, it is plain that they cannot well be limited as to their place of origin in the manner alleged, but that some of their filaments are connected with the anterior column. As to the posterior roots, they are mostly attached to the lateral column, but in some parts of the cord, they undoubtedly are connected also with the posterior column. This indeed corresponds with Bellingeri's opinion, who believes that each root (both anterior and posterior) has three deep connexions, one with the gray matter and one with each of the adjacent white columns ; but, as already stated, the anterior roots have not yet been satisfactorily traced into the gray substance.

The course of the white fibres of the nerves within the cord is not yet clearly made out. Those which enter the gray matter are believed by some (Grainger) to terminate there ; whilst it has been generally supposed that those which are connected with the white substance ascend continuously up the cord to reach the brain. Others again believe (with Valentin) that the fibres which enter the gray matter are prolonged for some way upwards among its ganglionic corpuscles, and then pass into the white columns, with which they at length become continuous.

The recently published views of Drs. Stilling and Wallach are totally different from those above mentioned. According to these observers, the roots of the nerves have no direct connexion with the white matter, and none of them run upwards in the cord. On the contrary, the fibres of all four roots enter the gray matter, and run horizontally through, in such a manner as to be completely interlaced or intermixed within it. Thus, to follow one of the posterior roots, it is said that, having entered the corresponding gray cornu, its fibres are disposed in three ways;—some, keeping on the same side of the cord, pass forwards through the anterior cornu and form part of the anterior root of that side ; whilst others, crossing through the gray commissure into the opposite half of the cord, run through its two gray cornua and assist in forming its anterior and posterior roots. The fibres of all four roots have a similar arrangement, so that some fibres of each root are continuous with some of the other three.

It is to be observed, however, that the method of investigation pursued by Stilling and Wallach, viz., that of examining thin transverse sections of the cord by means of a low power of the microscope, is not well adapted to determine the connexion and course of the nervous fibres. Moreover, it has been shown, by subsequent observations made on the spinal cord of the frog,† for the purpose of testing the accuracy of Stilling's views, that the roots of the nerves pass at least a short distance upwards, and that, at any rate, some of their white fibres are continuous with the longitudinal fibres of the cord.

It must be remembered, however, that there is no direct anatomical evidence to prove, that the fibres are continued all the way up to the brain.

INTERNAL STRUCTURE OF THE MEDULLA OBLONGATA.

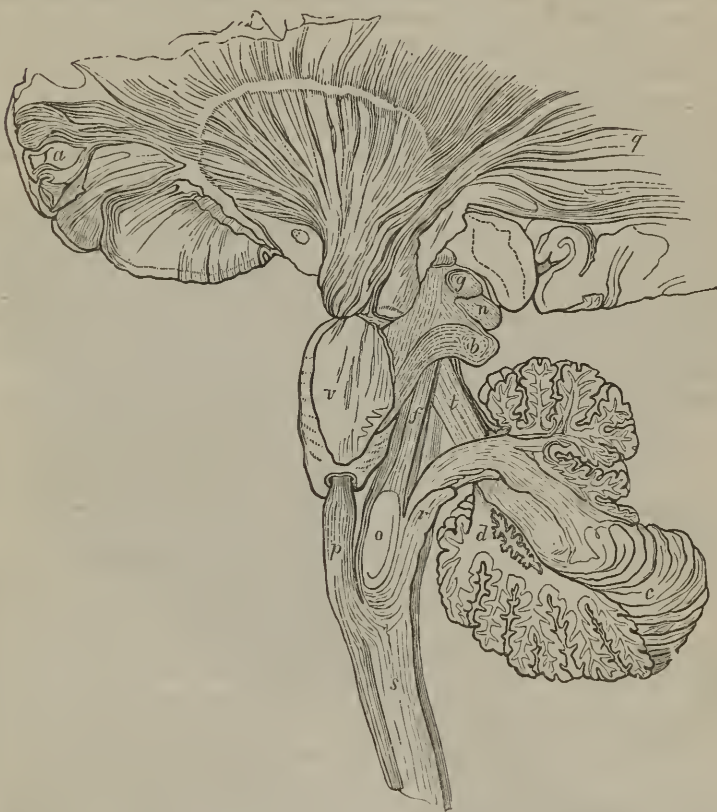
The white and gray constituents of the spinal cord, when they have

* On the Spinal Cord. 1837. † Budge—Müller's Archiv., 1844, p. 160.

reached the medulla oblongata become increased in size, and are altered in their arrangement, in the manner now to be described. The three white columns of the cord are disposed as follows.

1. The *posterior column*, figs. 342, 343, *e*, consisting of the fasciculus cuneatus and the slender fasciculus which higher up is named posterior pyramid, forms the restiform body. This, being joined by some fibres from the lateral column, and, as indicated by Solly, by a few from the anterior column, enters the cerebellum as its inferior peduncle, fig. 338, *r*,—the part called the posterior pyramid, *p*, fig. 343, excepted,

[Fig. 338.



Analytical diagram of the encephalon—in a vertical section. (After Mayo.)
s. Spinal cord. *r*. Restiform bodies passing to *c*, the cerebellum. *d*. Corpus dentatum of the cerebellum. *o*. Olivary body. *f*. Columns continuous with the olivary bodies and central part of the medulla oblongata, and ascending to the tubercula quadrigemina and optic thalami. *p*. Anterior pyramids. *v*. Pons Varolii. *n*, *b*. Tubercula quadrigemina. *g*. Geniculate body of the optic thalamus. *t*. Processus cerebelli ad testes. *a*. Anterior lobe of the brain. *q*. Posterior lobe of the brain.—T. & B.]

which according to careful inquirers* passes up with the fasciculi teretes to the cerebrum.

* Burdach—Bau und Leben des Gehirns, 1819; Arnold,—Foville,—Förg—Operibus citatis.

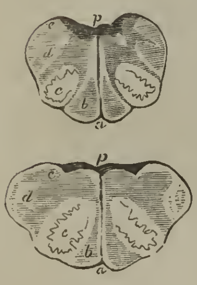
2. The *lateral column* ascends towards the base of the olivary body, and is disposed of in three ways; some of its fibres from the surface and deep part join in the restiform body and go to the cerebellum; a larger number, fig. 341, *x*, come forwards between the anterior columns, and crossing the median plane, form the chief part of the opposite anterior pyramid, *b;* the remaining fibres pass up to the cerebrum, as the fasciculi teretes, (fig. 338, behind *f*; faisceaux innominés,) appearing on the back of the pons Varolii, in the upper part of the floor of the fourth ventricle, fig. 343, *a*.

3. The *anterior columns*, having reached the apex of the anterior pyramids, are thrust aside from their median position by the decussating fibres derived from the lateral columns, and are then distributed in three divisions. One, very small, ascends obliquely backwards beneath the olive, and joins the restiform body (Solly). Another division passes directly up, its fibres embracing the olivary nucleus, fig. 338, above which they are again collected together, and joined by other fibres arising from the corpus dentatum, so as to form the olivary fasciculus, *f*; this ascends through the pons and at the side of the cerebral peduncle under the name of the fillet, fig. 342, *c*, *i*, *h*, and reaches the corpora quadrigemina by *i*, and the cerebral hemispheres by *h*. The remaining division of the anterior column ascends into the anterior pyramid, *p*, fig. 338, forming its outer part. The anterior pyramids, therefore, are composed of fibres from the lateral and anterior columns, and are continued up through the pons into the peduncles of the cerebrum.

It is to be remembered, however, that the separation between these different tracts of white fibres cannot be clearly followed out through the whole structure of the medulla oblongata; for, at a certain depth from the surface, they are found to be more or less blended with one another.

Fig. 339.

A



B

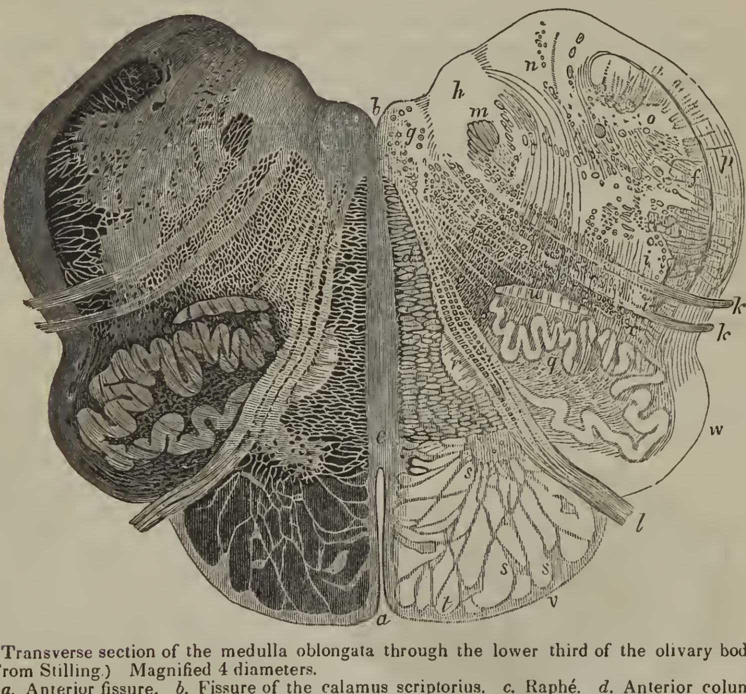
Section of the medulla oblongata — natural size — (Arnold). A. About middle of medulla. B. Higher up. *a*. Anterior fissure. *b*. Anterior pyramid. *c*. Olivary body and corpus dentatum. *d*. Gray tubercle. *p*. Posterior fissure in floor of fourth ventricle, where gray matter is accumulated.

Gray matter of the medulla oblongata.—In ascending into the medulla oblongata, the gray matter becomes more abundant, and gets blended with all the white fasciculi, excepting the anterior pyramids, fig. 339, *b b*, which are composed entirely of white substance. The posterior horns increase in size, and are directed more to the side, where they appear at the surface in the form of a narrow gray stripe, which was called by Rolando, *tuberculo cinereo*, *d*. A distinct mass of gray substance, forming the *corpus dentatum*, *c c*, exists within the olivary body. The gray commissure of the cord, as it is continued upwards, becomes exposed at the back of the medulla, *p p*, in the floor of the fourth ventricle, owing to the divergence of the posterior white fasciculi; and it eventually disappears as a distinct median structure, being mixed with the white fibres of the fasciculi teretes.

According to the observations of Stilling, some

part of the gray matter at the back of the medulla, forms special deposits or nuclei, connected with the roots of the spinal accessory, vagus, glosso-pharyngeal and hypoglossal nerves. Of these nuclei, the first or lowest is concealed in the substance of the medulla; whilst those which are situated higher up gradually appear as small triangular eminences, in the floor of the fourth ventricle, near the point of the calamus scriptorius.—See fig. 330, in which v' shows the position of the nucleus for the spinal accessory, i that for the vagus, e that for the glosso-pharyngeal, and c that for the hypoglossal nerve. The *first nucleus* is that for the spinal accessory nerve. It reaches some way down in the cord, and then appears, on a transverse section, like a

[Fig. 340.



Transverse section of the medulla oblongata through the lower third of the olivary bodies. (From Stilling.) Magnified 4 diameters.

a. Anterior fissure. *b.* Fissure of the calamus scriptorius. *c.* Raphé. *d.* Anterior columns. *e.* Lateral columns. *f.* Posterior columns. *g.* Nucleus of the hypoglossal nerve, containing large vesicles. *h.* Nucleus of the vagus nerve. *i, i.* Gelatinous substance. *k, k.* Roots of the vagus nerve. *l.* Roots of the hypoglossal, or ninth nerve. *m* A thick bundle of white longitudinal fibres connected with the root of the vagus. *n.* Soft column (*Zartstrang*, Stilling). *o.* Wedge-like column (*Keelstrang*, Stilling). *p.* Transverse and arciform fibres. *q.* Nucleus of the olivary bodies. *r.* The large nucleus of the pyramid. *s, s, s.* The small nuclei of the pyramid. *u.* A mass of gray substance near the nucleus of the olives (*Oliven-Nebenkern*). *u, q, r,* are traversed by numerous fibres passing in a transverse semicircular direction. *v, w.* Arciform fibres. *x.* Gray fibres.—T. & B.]

lateral process extending from the gray crescent between its anterior and posterior horns, and from it the slender and straggling roots of the nerve run outwards to the surface; as it extends upwards, it approaches the middle and back part of the medulla oblongata, v'.

In front of this nucleus, and close to the centre of the medulla, is another, the *second*, fig. 340, *g*, commencing higher up and connected with the hypoglossal nerve, the roots of which, coming forwards between the anterior pyramid and the olivary body, appear at the surface in the depression between those parts. Continuing to ascend, these two nuclei reach the back of the medulla, and then make their appearance in the floor of the fourth ventricle. Higher up, the nucleus for the spinal accessory nerve is succeeded by a *third* in the same line, *h*, which is connected with the nervus vagus, and is also placed to the outer side of that for the hypoglossus, *g*. Further out, a *fourth* nucleus, *n*, begins to be observed, belonging to the glosso-pharyngeal nerve. The last change in the arrangement of these small gray masses consists in the gradual narrowing of the nucleus of the par vagum, and the approximation of those for the hypoglossal and glosso-pharyngeal nerves, which were chiefly separated by it.

Langenbeck and Förg maintain, that the part regarded by Stilling as the nucleus for the glosso-pharyngeal nerve, is really the place of origin of the greater root of the fifth or trigeminal nerve.

The *horizontal white fibres* which form the antero-posterior septum, fig. 340, *c*, in the medulla oblongata, will be described along with a similar set of fibres existing in the pons.

INTERNAL STRUCTURE OF THE PONS VAROLII.

The pons Varolii consists of transverse white fibres, and of the longitudinal fibres prolonged through them from the medulla, intermixed with much gray matter.

Fig. 341.

Fibres of medulla oblongata and pons, arranged in alternate layers.—(Arnold.) *b*. Anterior pyramid. *b'*. Prolongation of same through pons. *c*. Olivary bundle. *d*. Olive. *m'*. Deeper transverse fibres. *m''*. Prolonged as middle peduncle of cerebellum. *p*, *q*. Their continuation into laminæ or folia of same. *n*. Inferior peduncle. *x*. Decussating portion of left lateral column, crossing over to right anterior pyramid.

On dissecting it from the front, a superficial white layer, figs. 341, 342, *m*, also fig. 329, *p*, *i*, is met with, which extends on either side into the middle crus of the cerebellum. Behind this are seen the prolonged fibres of the anterior pyramids, *b*, which, as they ascend through the pons, are widely separated into smaller bundles, intersected by other transverse white fibres, *m'*, which, like those upon the surface, are continued into the cerebellum. Amongst these two decussating sets of fibres is a large quantity of gray matter.

The arrangement just described extends to a considerable depth in the pons, but is succeeded by a third layer, which consists entirely of longitudinal fibres. This comprehends the olivary fasciculus, fig. 342,

c, *i*, *h*, and the fasciculi teretes, *t*, which, as we have frequently mentioned, run up on each side and in the floor of the fourth ventricle, intermixed with much gray substance.

Septum of the medulla oblongata and pons.—Besides the white fibres already described, there exist in the medulla oblongata and pons others which extend from behind forwards, fig. 340, *i*, in the median plane. In the medulla, fig. 332, these appear above the decussation of the pyramids. Some, issuing from the anterior fissure and turning round the sides of the medulla, form the arciform fibres, and those (sometimes named *fibræ transversæ*) which occasionally cover the anterior pyramids and olivary bodies; others, appearing at the surface, in the floor of the fourth ventricle, give rise to the transverse white striæ generally seen in that situation. These parts have been already described (p. 201).

A median septum of the same kind, obviously exists throughout the whole height of the pons, in its back part, but becomes indistinct in approaching the front or basilar surface, except towards its upper and lower edge, where the superficial fibres of the pons are manifestly continuous in the median line with these septal fibres; and bundles of white fibres, belonging to the same system, encircle the crura cerebri at their emergence from the upper border of the pons.

According to Foville, a few of the fibres from each of the three principal longitudinal elements of the medulla turn forwards and become continuous with the transverse fibres of the pons; and, in like manner, one or more small bundles from each of the cruri cerebri take a similar transverse course.*

INTERNAL STRUCTURE OF THE CEREBELLUM.

The cerebellum consists of an internal white medullary mass, containing on each side the corpus dentatum; of an external gray or cortical layer, covering the leaves or folia; and of three pairs of white peduncles.

The *folia* consist of white matter covered externally with gray. The structure of each of them appears to be this:—from the central white mass of the cerebellum, thin plates, composed of white fibres, pass up in the centre of the folia, and divide into subordinate white laminæ, corresponding with the subdivisions of the folia. Many of these *central white laminæ* can be traced continuously from the peduncles of the cerebellum. Upon these central plates are laid other *collateral lamellæ*, which are not connected with the fibres proceeding from the middle of the cerebellum, but merely pass from one folium to another. Superficial to these white fibres is the gray cortical substance.

This *gray* matter is not uniform throughout its whole thickness, but is composed of two or more layers, differing in colour and other characters;—resembling, in this respect, the cortical substance of the posterior convolutions of the cerebrum.

The *white* fibres, composing the peduncles of the cerebellum, are thus arranged in its interior.

The *middle* peduncles, fig. 341, *m*, which are the most superficial,

* Foville, op. cit., Pl. II., figs. 2 and 3. Pl. III., figs. 5 and 6.

pass from the pons Varolii, with the transverse fibres of which they are directly continuous, and enter the lateral parts, *m*, *p*, of the cerebellum. They may be traced into the folia of those parts, *q*, and form a large share of each hemisphere.

Fig. 342.

Arrangement of columns of medulla; and of superior and inferior peduncles of cerebellum.—(Arnold.) *a.* Part of the anterior column, which ascends to the olive. *b.* Decussating portion of lateral column. *c.* Olivary fasciculus. *d.* Olive. *e.* Restiform body. *f, g.* Corpora quadrigemina. *c, h, i.* Fillet. *h.* Part which goes to cerebral peduncle. *i.* Part going to corpora quadrigemina. *m m'.* Transverse fibres of pons, cut through. *n.* Inferior peduncle of cerebellum. *o.* Septal fibres of medulla oblongata. *q q.* Fibres of inferior peduncle continued into cerebellum. *r r.* Superior peduncle. *u.* Thalamus. *v.* Corpus albicans.

The middle peduncles being removed, the *inferior* peduncles (restiform bodies) come into view, figs. 338, 341, 342, *n*. They pass upwards into the middle part of the cerebellum, in the folia of which they are distributed, especially to those of the upper surface.

The *superior* peduncles, figs. 338, *t*, 342, *r*, which are placed nearest to the middle line, are principally connected with the folia of the inferior vermiform process; but a considerable number of them pass into or issue from the gray capsule of the corpus dentatum, which has been already described.

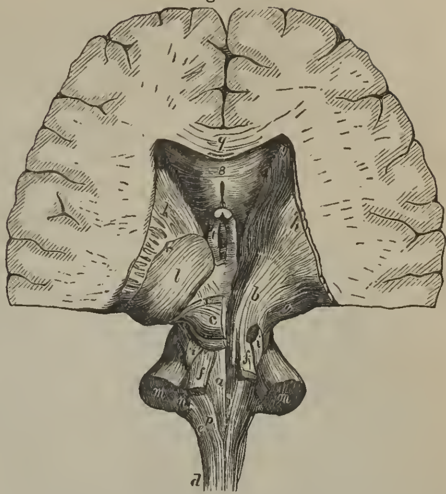
INTERNAL STRUCTURE OF THE CEREBRUM.

The fibres of the cerebrum, though exceedingly complicated in their arrangement, and forming many different collections, may be referred to three principal systems, according to the general course which they take, viz.,—1. *Ascending or peduncular fibres*, which pass up from the medulla oblongata to the hemispheres, and constitute the two crura or peduncles of the cerebrum. They increase in number as they ascend through the pons, and still further in passing through the optic thalami, and striated bodies, beyond which they spread in all directions into the hemispheres. These were named by Gall the *diverging* fibres. 2. *Transverse* or *commissural* fibres, which connect the two hemispheres together. These are the converging fibres of Gall. 3. *Longitudinal* or *collateral* fibres, which, keeping on the same side of the middle line, connect more or less distant parts of the same hemisphere together.

1. The *peduncular* fibres consist of a main body and of certain accessory bundles of fibres.

a. The *main body* on each side is derived from the anterior pyramid, fig. 338, *p*, from the prolongation of the lateral column (one of the fasciculi teretes, fig. 343, *a*,) and from the posterior pyramid, *p*. After it has passed through the pons and become increased in amount, it is separated into two parts in the crus cerebri by a layer of dark cineritious matter, named *locus niger*. The lower or superficial part, which is derived from the pyramid, consists almost entirely of white fibres, col-

Fig. 343.



Back view of peduncular fibres of cerebrum, attached to hemispheres.—(Arnold.) *a.* Fasciculus teres of left side. *b.* Fibres of tegmentum ascending through thalamus. *c.* Left corpora quadrigemina. *e.* Restiform body. *f f.* Superior peduncles of cerebellum—processus ad testes. *g.* Fibres of crust. *i i.* Fillet of both sides. *k k'.* Corpora striata:—on the right side, the gray matter stripped off to show radiating fibres of fibrous cone. *l.* Left thalamus. *m m.* Sections of middle peduncles of cerebellum. *n.* Section of left inferior peduncle. *p.* Left posterior pyramid. *q.* Corpus callosum. *s.* Under surface of the same—below *s*, cavity of fifth ventricle. *t.* Left anterior pillar of fornix. *y y.* Decussation of radiating fibres, with those of corpus callosum.

lected into coarse fasciculi, and is named the *crust* or *basis*, fig. 343, *g*, or the *fasciculated portion* of the peduncle (Foville). The upper part, composed principally of the fasciculus teres and posterior pyramid, is named the *tegmentum, b;* it is softer and finer in texture, and is mixed with much gray matter.

Still increasing in number within the peduncle, these two sets of fibres continue to ascend, fig. 338, and pass above the optic tracts through the thalamus, fig. 343, *b*, *l*, and corpus striatum, *k*, *h*. Receiving fresh accessions of fibres there, they are continued on into the medullary substance of the corresponding hemisphere, fig. 338. The anterior fibres, or those of the crust, fig. 343, *g*, pass principally, if not entirely, through the corpus striatum. The posterior fibres, or those of the tegmentum, run, some through the thalamus, but the greater part at least through the corpus striatum also.

As they pass through these large gray masses or ganglia, the two sets of fibres intersect or cross each other, and on emerging beyond the gray matter, fig. 343, *y*, they again decussate with the commissural fibres or transverse fibres, *s*, of the corpus callosum, *q*. After that, they spread into the hemisphere in every direction, and reach the cortical substance of the convolutions.

The accessory fibres of the peduncular system are as follows:—

b. The superior peduncles of the cerebellum, (processus ad testes,) figs. 338, 343, *f*, which are continued up beneath the corpora quadrigemina, *q*, *c*, and form part of the tegmentum.

c. The bundle of fibres on each side, named the *fillet*, lemniscus, schleife, *i*.—This, which is originally derived from the anterior column of the cord, forms the olivary fasciculus, fig. 342, *c*, of the medulla oblongata, as previously described. Reinforced by fibres from the corpus dentatum of the olivary body, *d*, it ascends through the back part of the pons, still increasing in size. Appearing at the side of the cerebral peduncle, above the upper border of the pons, fig. 343, *i*, *i*, it divides into two portions, of which one, fig. 342, *i*, crosses over

the superior peduncle of the cerebellum to the corpora quadrigemina, meeting its fellow of the opposite side; whilst the other, *h*, is continued upwards with the fibres of the tegmentum.

d. Other accessory fibres to the peduncles take their rise in the gray matter of the corpora quadrigemina, *g*, *f*, (the *brachial*,) and proceed on to the thalami, *u*.

e. Lastly, another set, having a similar destination, are derived from the corpora geniculata.

Corpus striatum and *corona radiata.*—The principal mass of each corpus striatum is concealed in the substance of the cerebral hemisphere, whilst a part of it, fig. 343, *k*, *k*, appears in the lateral ventricle. The ascending white fibres of the corresponding peduncle, spreading out in a radiating manner, pass up through and between these two parts of the corpus striatum, and divide the gray matter into an extra- and an intra-ventricular portion.

The assemblage of these radiating fibres, fig. 338, might be compared to a fan, bent into the form of an incomplete hollow cone, having its concave surface turned downwards and outwards; hence the name *corona radiata* applied to them by Reil, and *fibrous cone*, by Mayo. On cutting through the corpus striatum across the direction of these fibres, the section of the fibrous cone appears as a broad white band, extending from the anterior to the posterior extremity of that gray mass, and separating it into its outer and inner portions already mentioned. On dissecting the corpus striatum from the ventricle, and removing its intraventricular gray substance, we meet, at some depth from the surface, with these white fibres, which being intermixed with the gray matter, give to the body its streaked appearance. The extraventricular portion, which lies somewhat lower than the inner portion, is situated between the radiating peduncular fibres, and the island of Reil, and may be exposed by dissecting the hemisphere from the Sylvian fissure. In this dissection, the convolutions of the island are first removed; beneath the white matter of those gyri, a thin layer of gray substance is met with, which has been named the *claustrum* (Burdach): deeper than this, white matter again appears,—forming, however, but a very thin layer,—on removing which the extraventricular portion of the corpus striatum is exposed. In this dissection the striated body is also seen to be continuous below with the anterior perforated space, where the gray matter reaches the surface of the brain; whilst around its upper margin, now completely exposed, appears a zone of white radiating fibres, which is the continuation of the corona radiata, after its passage through the gray matter. On next scraping away the latter, the fibrous cone is entirely displayed from its outer side. In doing this, the fibres of the anterior commissure, of which we shall presently make mention, also come into view.

Lastly, it may be mentioned, that if the brain be cut through in a plane perpendicular to the surface of the island, the section of the gray layer, named the claustrum, appears as a narrow dark line situated between the island and the corpus striatum.

2. The *transverse*, *commissural* or connecting fibres of the cerebrum include the following sets :—

a. The cross fibres of the corpus callosum, fig. 343, *q*.—These are more numerous at each end of the corpus callosum than in the middle, and form the thickest mass behind. Passing laterally into the substance of the hemispheres, some are directed upwards, whilst others spread outwards on the roof of the lateral ventricles, forming there what is named the *tapetum*, *s*. Having next intersected the peduncular radiating fibres at *y y*, they then spread out into the hemispheres, reaching the gray matter of the convolutions.

b. The *anterior commissure*, fig. 344, *x*.—This is a round bundle of white fibres, seen in the fore part of the third ventricle, from which it passes laterally into the corpora striata, and bending backwards, extends a long way in the hemispheres, reaching into the middle lobe on each side.

c. The *posterior commissure*, also situated in the third ventricle, runs through the optic thalami, and is soon lost in the substance of the hemispheres in that situation.

3. The third system of fibres in the cerebrum, the *longitudinal* or *collateral*, may be comprehended under the following heads.

a. The *fornix*, fig. 345, *t t'*.—This forms a longitudinal bundle on each side, which, as already mentioned, might be described as commencing in the thalamus, *, near its anterior tubercle. It then descends to the corpus albicans, *n*, of its own side, turns round in that eminence, and ascending to form the anterior pillar, *t*, may thence be traced backwards in conjunction with that of the opposite side, until it separates posteriorly, where it spreads out in part upon the pes hippocampi in the descending cornu of the lateral ventricle, and is prolonged as the corpus fimbriatum nearly to the point of the middle lobe.

Fig. 344.

Under surface of left hemisphere dissected. —(After Mayo.) *a.* Anterior, and *a'*, posterior part of fillet of corpus callosum. *b, g.* Section of cerebral peduncle. *b.* Tegmentum. *g.* Crust, separated by locus niger. *c'.* Fibres reaching from back of corpus callosum to posterior lobe. *e.* Fasciculus uncinatus, connecting anterior and middle lobes, across the Sylvian fissure. *f f.* Transverse fibres from corpus callosum. *l.* Back of thalamus. *m.* Corpus albicans. *q.* Corpus callosum. *r.* Radiating fibres of hemisphere. *t.* Anterior pillar of fornix. *v.* Collateral fibres of convolutions. *x.* Anterior commissure. 2. Part of optic tract.

b, c. The white fibres constituting the *tænia semicircularis*, fig. 333, *s*, and those of the peduncles of the pineal gland, fig. 336, *p*, may perhaps be regarded as accessories to the fornix. They both join its anterior pillars in front. Behind, the tænia is lost on the back of the

thalamus in the descending cornu; and the pineal peduncles end in the pineal gland, so that they are regarded by some as forming a transverse commissure.

Foville traces the tænia from part of the posterior pyramids, as will be presently noticed.

d. The *striæ longitudinales,* upon the upper surface of the corpus callosum, also belong to this system. They are distinguished into the middle and lateral longitudinal striæ. In front, they are connected with the peduncles of the corpus callosum, and through them with the anterior perforated space. Their posterior connexions are uncertain; according to Foville, they join the posterior pillars of the fornix.

e. Fibres of the gyrus fornicatus; fillet of the corpus callosum (Mayo). These fibres constitute the white substance of the gyrus fornicatus, and take a longitudinal course, fig. 345, *a a′ a a″*, immediately above the transverse fibres of the corpus callosum, *q*. In front, *a*, they bend downwards within the gyrus to which they belong, and are connected with the anterior perforated space, being joined by certain longitudinal fibres, which run along the under surface of the corpus callosum near the middle line, passing near and upon the upper edge of the septum lucidum. Behind, *a c*, they turn round the back of the corpus callosum and descend to the point of the middle lobe, *a″*, where, according to Foville, they again reach the perforated space. Offsets, *c c c*, from these fibres pass upwards and backwards into the secondary convolutions in the longitudinal fissure derived from the gyrus fornicatus.

f. Fasciculus uncinatus.—Under this name is described a white bundle, fig. 344, *e*, seen on the lateral aspect of the hemisphere, passing across the bottom of the Sylvian fissure, and connecting the ante-

Fig. 345.

Dissection of fibres of gyrus fornicatus, and of fornix. (From Foville, slightly altered.) A. Anterior, B. Posterior lobe. *a a′ a″*. Fibres of gyrus fornicatus. *c*. Of its accessory gyri. *b*. Tegmentum; and *g*. crust—the two separated by locus niger. *l*. The thalamus. *n*. Corpus albicans. *q*. Corpus callosum. *r*. Radiating fibres of hemisphere. *s*. Septum lucidum. *t*. fornix. *t′*. Anterior pillar. * Commencement in thalamus. 1. Olfactory nerve. 2. Optic commissure.

rior with the middle and posterior lobes. The fibres of this bundle expand at each extremity, and the superficial portion of them curve

or hook sharply between the contiguous parts of the anterior and middle lobes,—whence it has received its name.

g. The convolutions of the cerebrum are connected with each other by white fibres, which lie immediately beneath the cortical substance. Some of them, fig. 344, *v*, pass across the bottom of a sulcus between adjacent convolutions; whilst others, which are long and run deeper, connect convolutions situated at a greater distance from one another.

The central part of the white substance of each convolution is formed by fibres having a different origin; some, fig. 338, being derived from the radiating peduncular fibres, and, according to most anatomists, others from the transverse fibres of the corpus callosum.

The researches of Foville have led him to differ considerably from other anatomists, as to the course of the fibres of the cerebrum, as will be seen from the following statement of his views:—

1. The *crust*, or *fasciculated portion* of each cerebral peduncle, derived from the anterior pyramid, forms by itself the peduncular fibrous cone, and is thence continued on into the radiating fibres of the cerebrum, which are destined only for the convolutions on the convex surface of the hemisphere, including the outer half of the marginal convolution of the longitudinal fissure, and the inner half of the convolution of the Sylvian fissure.

2. The fibres of the *tegmentum*, having entered the thalamus, pass on in two ways—no part of them, be it observed, joining the radiating peduncular fibres.

a. One set pass upwards through the thalamus and corpus striatum, above which they turn inwards, and, joining with those of the opposite side, form the transverse fibres of the corpus callosum. The corpus callosum is therefore regarded as a commissure of the cerebral peduncles only—none of its cross fibres spreading into the convolutions, as is generally believed.

b. The second set of fibres of the tegmentum, corresponding with the fasciculi teretes and part of the posterior pyramids, run forwards near the middle line, along the under side of the third ventricle and corpus striatum, through the gray matter in front of the pons, to the anterior perforated space. The remaining part of the posterior pyramid forms the tænia semicircularis, which, passing down in front of the anterior pillar of the fornix, also reaches the perforated space. From this space more fibres are reflected upwards on the sides of the corpus striatum to join the corpus callosum.

3. As dependencies of the posterior peduncular fibres, and connected with them at the borders of the anterior perforated space, are:—

a. Several sets of longitudinal arched fibres, which embrace, in a series of rings, the radiating peduncular system. These are—the deep fibres of the tænia semicircularis—a somewhat similar band beneath the outer part of the corpus striatum—the half of the fornix with the corpus fimbriatum—the longitudinal fibres placed on the upper and under surface of the corpus callosum, and those of the septum lucidum; and, lastly, two remarkable systems of longitudinal fibres—one constituting the entire white substance of the gyrus fornicatus (from end to end), also, of its accessory convolutions, and of the inner half of the marginal convolution of the longitudinal fissure; and the other, forming the white substance of the convolutions of the island of Reil, and the adjoining half of the convolution of the Sylvian fissure. None of the parts just named receive fibres from the radiating peduncular set.

b. In connexion with this system is a thin stratum of white fibres, found upon the internal surface of the ventricles, and prolonged through the transverse fissure into the reticulated white substance covering the lower end of the gyrus fornicatus; whence, according to Foville, it extends, as an exceedingly thin layer of medullary matter, all over the cortical substance of the hemisphere.

c. The anterior commissure does not reach the convolutions, but radiates upon the outer sides of the corpora striata and thalami.

Gray matter of the encephalon.—Considering the imputed physiological importance of the gray nervous substance, it may be well to

mention connectedly the different positions in which it is found in the several parts of the encephalon.

By far the larger amount is situated upon the convoluted surface of the cerebrum and the laminated surface of the cerebellum, forming in each case the external cortical layer of cineritious matter.

In the middle part of the base of the brain it is seen to be accumulated along the under side of the third ventricle, in a layer of varying thickness, extending from a little above the optic commissure to the back part of the interpeduncular space, forming the lamina cinerea, the tuber cinereum, and the gray matter in the posterior perforated space, the infundibulum and pituitary body being continuous with it below. Towards each side, in front, the lamina cinerea is connected with the gray matter of the anterior perforated space, whence a continuity of the cineritious substance may be traced forwards into the olfactory nerve, as far as its obtuse extremity, the olfactory lobe. Moreover, this median stratum of gray matter seen on the floor of the third ventricle is prolonged upwards on the sides of the thalami, passes across as the soft commissure, partly surrounds the anterior pillar of the fornix, (having entered below into the interior of the corpus albicans,) and is extended higher up on the sides of the septum lucidum. In the crura cerebri, the gray matter is collected into a dark mass, the locus niger, and is also diffused among the fasciculi of the tegmentum; below this it is continuous with that of the pons and medulla oblongata, and through them with that of the spinal cord, as has already been sufficiently described.

In the centre of each of the corpora quadrigemina, gray matter is also found, and it occurs in the pineal gland, and in the corpora geniculata. These last bodies appear to be appendages of the large masses of gray matter situated in the interior of the cerebrum, named the optic thalami; which again are succeeded by the still larger collections of this substance, and indeed the largest situated within the brain, viz., the corpora striata. The gray matter of each corpus striatum is continuous below with that of the anterior perforated space; and on its outer side, is the thin layer of gray matter named the claustrum, the connexions of which are not well understood.

In the centre of each hemisphere of the cerebellum is the corpus dentatum.

CONNEXIONS OF THE CRANIAL NERVES WITH THE ENCEPHALON.

The *cranial* nerves arise from the under part of the brain and issue through the foramina in the base of the skull. They are usually reckoned as forming *nine* pairs (see fig. 331, where they are numbered [1] to [9]). The several designations of these nerves as well as their course within the cranium will be subsequently described. It is here proposed to give an account of their connexions with the encephalon, or what is usually called their root or *origin*.

The roots of the nerves may be traced for some depth into the substance of the encephalon, a circumstance which has led to the distinction of the *deep* or *real* origin, and the *superficial* or *apparent*

origin, by which latter is understood the place at which the nerve appears attached to the surface of the encephalon. The superficial origin of these nerves is quite obvious, but their deeper connexion is, in most cases, a matter of much uncertainty. For this reason the apparent origin is described before the deep origin, which is less perfectly known.

1. The first or *olfactory* nerve, figs. 331, 332, [1], small in man in comparison with lower animals, lies on the under surface of the anterior lobe to the outer side of the longitudinal median fissure, lodged in a sulcus between two straight convolutions. Unlike other nerves, it consists of a large proportion of gray matter mixed with white fibres, and, indeed, is rather to be considered a prolongation of the anterior lobe. It enlarges into a *bulb, olfactory bulb*, in front, which also contains much gray matter, and from this part small soft nerves descend through the cribriform plate of the skull into the nose. On turning back the bulb, it is seen that the nerve behind that part is three-sided, its upper edge lying in the groove or sulcus above-mentioned. When traced backwards, it is found to be spread out and attached behind to the under surface of the anterior lobe by means of *three* portions or *roots*, named external, middle, and internal, which pass in different directions.

The *external* or *long* root consists of a band of medullary fibres, which passes, in the form of a white streak, outwards and backwards along the anterior margin of the perforated space, towards the posterior border of the Sylvian fissure, where it may be followed into the substance of the cerebrum. Its further connexions are doubtful, but it has been stated that its fibres have been traced to the following parts, viz., the convolutions of the island of Reil, the anterior commissure, and the superficial layer of the optic thalamus (Valentin).

The *middle* or *gray* root is of a pyramidal shape, and consists of gray matter on the surface, which is prolonged from the adjacent part of the anterior lobe and perforated space. Within it there are white fibres, which have been traced to the corpus striatum.

The *internal root* (*short* root, Scarpa), which cannot always be demonstrated, is composed of white fibres which may be traced from the inner and posterior part of the anterior lobe, where they are said by Foville to be connected with the longitudinal fibres of the gyrus fornicatus.

[The following observations upon the connexions and structure of the olfactory bulb and pedicle were made upon several human brains a few hours after death, and may not prove uninteresting as a point of special anatomy.

The olfactory pedicle or commissure is triangular, its apex and two sides being received into a fissure of the anterior inferior part of the marginal convolution of the longitudinal fissure, and its base being inferior. Postero-superiorly it forms a large round prominence (fig. 347, A, *c*), externally composed of ganglionary substance, around the base of which the locus perforatus (fig. 347, B, *c*) is continuous.

The pedicle is composed of several distinct commissural bands.

The first or most external commissural band (fig. 346, *a*, fig. 347, B, *a*) of the olfactory bulb, or external root of the olfactory nerve, as it is improperly called, is composed of nerve-fibres, and curves from the outer part of the fissura Sylvii, at

[Fig. 346.

[Fig. 346 represents an inferior view of the right olfactory ganglion and commissure. *a*. External commissural band. *d*. Internal commissural band.—J. L.]

the exterior boundary of the locus perforatus, inwards and forwards. It forms two thirds of the external, and a narrow line of the inferior surface of the pedicle, and when it reaches the bulb, divides into two branches, which join the ganglionary substance of the latter. The most external of the two branches can be traced farthest into the bulb.

The internal commissural band (fig. 346 *d*; fig. 347, A, *a*,) emerging from the locus perforatus, is also composed of nerve-fibres, and running forwards forms the infero-internal boundary of the pedicle, and terminates in the bulb by dividing into three branches.

The external and internal commissural bands are separated from each other by a fissure running along the inferior surface of the pedicle, and are held in close apposition by an envelope of pia mater. When the latter is laid open and the bands pressed apart, the fissure disappears, and the two bands are presented as a single white layer, about two lines in width, and forming the inferior part of the olfactory pedicle.

[Fig. 347.

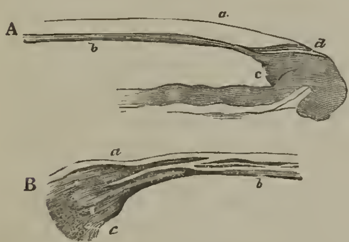


Fig. 347. A, represents the appearance of the internal face of the olfactory pedicle of the left side. *a*. Internal commissural band. *b*. Superior or middle gray band. *c*. Protuberant base of the olfactory pedicle. *d*. Escape of a white fibre from the gray substance going to join the white band.

B, represents the appearance of the external surface of the olfactory pedicle of the left side. *a*. External commissural band joined by white fibres escaping from the superior gray band (*b*) *c*. Continuation of the locus perforatus around the protuberant base of the olfactory pedicle.—From nature, by J. L.]

The middle or superior commissural band (fig. 347, A, *b*; B, *b*), forming the superior part of the olfactory pedicle, consists of ganglionary substance continuous with that of the locus perforatus and the olfactory bulb. At the posterior part of this band, upon each side, but especially the external one (fig. 347, B), white fibres are frequently found escaping from the gray substance, and running forwards with an inclination downwards, to join the white commissural bands.

At the conjunction of the commissural bands within the olfactory bulb, a small fissure or cavity is left lined with a delicate epithelium.

The olfactory bulb or ganglion, is composed of an intermixture of ganglionary corpuscles and nerve-fibres, and from its inferior surface the olfactory nerves originate. In the pia mater covering it, in the negro, I have frequently observed a deposit of pigment cells.—J. L.]

2. The *second* pair of nerves, or the *optic* nerves, ², of the two sides, meet each other at the optic commissure (chiasma), *c*, where they partially decussate. From this point they may be traced backwards around the crura cerebri under the name of the optic tracts.

Each *optic tract*, *u*, arises from the optic thalamus, the corpora quadrigemina, and the corpora geniculata. As it leaves the under

part of the thalamus, it makes a sudden bend forwards and then runs obliquely across the under surface of the cerebral peduncle, fig. 348, [2], in form of a flattened band, which is attached by its anterior edge to the peduncle; after this, becoming cylindrical, it adheres to the tuber cinereum, from which and, as was first pointed out by Vicq-d'Azyr,* from the lamina cinerea it is said to receive an accession of fibres, and thus reaches the optic commissure.

In the *commissure* the nerves of the two sides undergo a partial decussation. The outer fibres of each tract continue on to the eye of the same side; the inner fibres cross over to the opposite side; and fibres have been described as running from one optic tract to another along the posterior part of the commissure, and others between the two optic nerves in its anterior part (Mayo).

In front of the commissure, the nerves enter the foramen opticum, receiving a sheath from the dura mater and acquiring greater firmness.

The fibres of origin of the optic tract from the thalamus are derived partly from the superficial stratum, and partly from the interior of that body. According to Foville, this tract is also connected with the tænia semicircularis, and with the termination of the gyrus fornicatus; and he states further, that where the optic tract turns round the back of the thalamus and the cerebral peduncle, it receives other delicate fibres, which descend from the gray matter of those parts.—(Op. cit. p. 514.)

3. The *third pair* of nerves, [3], (motores oculorum,) have their *apparent* or superficial origin from the inner surface of the crura cerebri in the interpeduncular space, immediately before the pons, fig. 348, [3]. Each nerve consists of a number of funiculi which arise in an oblique line from the surface.

As to their *deep* connexions,—the fibres of origin are found to diverge in the substance of the crus, some being traced to the locus niger, others running downwards in the pons amongst its longitudinal fibres, and others, again, turning upwards to be connected with the corpora quadrigemina and Vieussenian valve.

4. The *fourth* pair, *pathetic* or *trochlear* nerves, figs. 331, 348, [4], the smallest of those which are derived from the brain, are seen at the outer side of the crura cerebri immediately before the pons. Each nerve may be traced backwards round the peduncle to below the corpora quadrigemina, where it arises from the upper part of the valve of Vieussens, fig. 330. The roots of the nerves of opposite sides are connected together across the middle line, in the form of a white band or commissure in the substance of the velum.

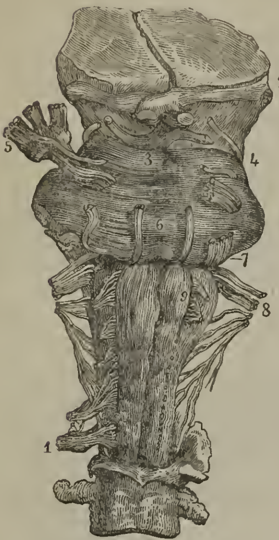
5. The *fifth* pair of nerves, *par* trigeminum, *trifacial nerves.* The superficial origin of these nerves, figs. 331, 348, [5], is from the side of the pons Varolii, where the latter is connected with the middle crus cerebelli, considerably nearer to the upper than to the lower border of the pons.

The fifth nerve consists of a larger or sensory, and a smaller or motor root, fig. 348. The smaller root is at first concealed by the larger, and is placed a little higher up, there being often two or three cross

* Op. cit. p. 72, pl. xxi.

fibres of the pons between them. On separating the two roots, the lesser one is seen to consist of a very few funiculi. In the *larger* root the funiculi are numerous, amounting sometimes to nearly a hundred. This root acquires its neurilemma sooner at the circumference than in the centre, so that the outward cords are longer than those within, and when the bunch of funiculi is pulled away, a small conical eminence of white substance remains behind.

Fig. 348.



Front view of crura cerebri, pons, medulla oblongata, and part of spinal cord (Bell). The origins of some of the cranial nerves are shown. 2. Optic nerve. 3. Motor oculi. 4. Pathetic nerve. 5. Fifth, or trifacial nerve. 6. Abducent nerve. 7. Auditory and facial nerves—seventh pair. 8. Eighth pair, including glosso-pharyngeal, vagus, and spinal accessory nerves. 9. Hypoglossal nerve. 1. A spinal nerve.

Deep origin. The *greater* root runs beneath the transverse fibres of the pons towards the lateral part of the medulla oblongata behind the olivary body. Several anatomists trace it into the floor of the fourth ventricle, between the fasciculi teretes and the restiform bodies. By some it is considered to be continuous with the fasciculi teretes and lateral columns of the cord, whilst others connect it with the gray mass which is regarded by Stilling as the nucleus of the glosso-pharyngeal nerve.

The *motor* root was supposed by Bell to descend to the pyramidal body, and Retzius believes that he has confirmed that opinion by dissection; but the deep connexion of this root is not known with certainty.

According to Foville, some of the fibres of the sensory root of the fifth nerve are connected with transverse fibres in the pons, whilst others spread out on the surface of the middle peduncle of the cerebellum, and enter that part of the encephalon beneath the folia.—(Op. cit. p. 506.)

6. The *sixth* nerve (abducens), *motor oculi externus*, figs. 331, 348, [6], takes its apparent origin from between the pyramidal body and the pons Varolii by means of a large and a smaller bundle. It really arises from the pyramid, and to a small extent from the pons also.

7. The *seventh* pair of nerves, [7], [7′], appear on each side at the posterior margin of the pons, opposite its junction with the middle peduncles of the cerebellum, and therefore in a line with the place of attachment of the fifth nerve. The seventh nerve is divided into two perfectly distinct portions, which, in fact, are two different nerves: the one, named the portio dura, is the muscular nerve of the face; the other, or portio mollis, is the nerve of hearing.

The *portio dura* or *facial* nerve, [7], placed a little nearer to the middle line than the portio mollis, may be traced to the medulla oblongata between the restiform and olivary fasciculi, with both of which it is said to be connected. Some of its fibres are derived from the pons.

Connected with the portio dura, and intermediate between it and the portio mollis, is a smaller white funiculus, first described by Wrisberg (portio inter duram et mollem). The roots of this accessory portion are connected deeply with the lateral column of the cord.

The *portio mollis*, figs. 331, 348, [7], or auditory nerve, rises from the floor of the fourth ventricle, at the back of the medulla oblongata, in which situation, as already described, numerous white striæ are seen, which form the commencement of the nerve, fig. 330. These roots are connected with the gray matter, and some appear to come out of the median fissure. The nerve then turns round the restiform body, and becomes applied to the lower border of the pons, receiving accessions from the former of those parts, and according to some authorities from the latter also.

Foville says that the roots of the portio mollis are also connected by a thin layer on the under surface of the middle peduncle with the cortical substance of the cerebellum; also, with the small lobule named the flocculus; and with the gray matter at the borders of the calamus scriptorius.

8. The *eighth* pair, figs. 331, 348, [8 8' 8''], of cranial nerves consists of a series of funiculi which arise along a lateral line from the medulla oblongata, and cervical part of the spinal cord.

The uppermost bundle is the *glosso-pharyngeal* nerve, [8]; next to this, and lower down, is the *par vagum* or *pneumogastric* nerve, [8'], consisting of a larger number of white cords. The roots of both these nerves are attached superficially to the fore part of the restiform body. Still lower, is the *spinal accessory* nerve, [8''], which comes up from the side of the spinal cord, enters the skull by the foramen magnum, and is associated with the vagus nerve, as it passes out through the foramen lacerum.

The accessory nerve arises within the spinal canal from the lateral column of the cord, near the posterior lateral fissure, by a series of slender roots, which commence about as low down as the sixth cervical nerve. The nerve passes upwards between the posterior roots of the cervical nerves and the ligamentum denticulatum,—its several funiculi of origin successively joining it as it ascends. On entering the skull, it receives funiculi from the side of the medulla oblongata.

These three portions of the eighth pair are connected *deeply* with gray nuclei within the cord and medulla oblongata, as already fully described (see p. 232).

9. The *ninth* nerve, figs. 331, 348, [9], (hypoglossal,) arises, in a line continuous with that of the anterior roots of the spinal nerves, by scattered funiculi from the furrow between the olivary body and the anterior pyramid.

Its roots are traced by Stilling to one of the gray nuclei already described in the medulla oblongata.

THE MEMBRANES OF THE BRAIN AND SPINAL CORD.

As already stated, the cerebro-spinal axis is protected by three *membranes*, named also *meninges* (μήνιγξ). They are:—1. An external fibrous membrane, named the *dura mater*, which closely lines the interior of the skull, and forms a loose sheath in the spinal canal; 2. An

internal cellulo-vascular tunic, the *pia mater*, which accurately covers the brain and spinal cord; and 3. An intermediate serous sac, the *arachnoid* membrane, which, by its parietal and visceral layers, covers the internal surface of the dura mater on the one hand, and is reflected over the pia mater on the other.

THE DURA MATER.

The *dura mater*, a very strong, dense, inelastic, fibrous tunic, of considerable thickness, is closely lined on its inner surface by the outer portion of the arachnoid, and with it, therefore, forms a *fibro-serous* membrane, which is free, smooth, and epitheliated on its inner surface, where it is turned towards the brain and cord, but which, by its outer surface, is connected in a different manner in the cranium, and in the spinal canal.

The outer surface of the *cranial* portion adheres to the inner surface of the bones, and forms their internal periosteum. The connexion between the two, in a great measure, depends on blood-vessels and small fibrous processes, which pass from one to the other; and the dura mater, when detached and allowed to float in water, presents a flocculent appearance on its outer surface, in consequence of the torn parts projecting from it.

The adhesion between the membrane and the bone is more intimate opposite the sutures, and also generally at the base of the skull, which is uneven, and perforated by numerous foramina, through which the dura mater is prolonged to the outer surface, being there continuous with the pericranium. The fibrous tissue of the dura mater becomes blended with the cellular sheaths of the nerves, at the foramina which give issue to them.

In leaving the skull, the dura mater is intimately attached to the margin of the foramen magnum; but within the vertebral canal it forms a loose sheath around the cord, (*theca*,) and is not adherent to the bones, which have an independent periosteum. Towards the lower end of the canal a few fibrous slips proceed from the outer surface of the dura mater to be fixed to the vertebræ. The space intervening between the canal and the dura mater is occupied by loose fat, by watery cellular tissue, and by a plexus of spinal veins.

Opposite each intervertebral foramen the dura mater presents two openings, placed side by side, which give passage to the two roots of the corresponding spinal nerve. It is continued as a tubular prolongation on the nerve, and is lost upon its sheath. Besides this, it is connected with the circumference of the foramen by cellular tissue.

The fibrous tissue of the dura mater, especially within the skull, is divisible into two distinct layers, and at various places these layers separate from each other and leave intervening channels, called *sinuses*. These sinuses, which have been elsewhere described, are canals for venous blood, and are lined with a continuation of the internal membrane of the veins.

The dura mater also sends inwards into the cavity of the skull three strong membranous *processes*, or *partitions*, which are regarded as duplicatures of its inner layer. Of these, one descends vertically in

the median plane, and is received into the longitudinal fissure between the two hemispheres of the cerebrum. This is the *falx cerebri*. The second is an arched or vaulted partition, stretched across the back part of the skull, between the cerebrum and the cerebellum: it is named the *tentorium cerebelli*. Below this, another vertical partition, named *falx cerebelli*, of small extent, passes down between the hemispheres of the cerebellum.

The *falx cerebri* is narrow in front, where it is fixed to the crista galli, and broader behind, where it is attached to the middle of the upper surface of the tentorium, along which line of attachment the straight sinus is situated. Along its upper convex border, which is attached above to the middle line of the inner surface of the cranium, runs the superior longitudinal sinus. Its under edge is free, and reaches to within a short distance of the corpus callosum, approaching nearer to it behind. This border contains the inferior longitudinal sinus.

The *tentorium*, or *tent*, is elevated in the middle, and declines downwards in all directions towards its circumference, in correspondence with the upper surface of the cerebellum. Its inner border is free and concave, and leaves in front of it an oval opening, through which the isthmus encephali descends. It is attached behind and at the sides by its convex border to the horizontal part of the crucial ridges of the occipital bone, and there encloses the lateral sinuses. Further forward it is connected with the upper edge of the petrous portion of the temporal bone—the superior petrosal sinus running along this line of attachment. At the point of the pars petrosa, the external and internal borders meet, and may be said to intersect each other—the former being then continued inwards to the posterior, and the latter forwards to the anterior clinoid process.

The *falx cerebelli* (falx minor) descends from the middle of the posterior border of the tentorium, with which it is connected, along the vertical ridge named the internal occipital crest, towards the foramen magnum, bifurcating there into two smaller folds. Its attachment to the bony ridge marks the course of the posterior occipital sinus, or sinuses.

Structure.—The dura mater consists of white fibrous tissue, arranged in bands and laminæ, crossing each other. It is traversed by numerous blood-vessels which are destined for the bones. Minute nervous filaments, derived from the fourth and fifth cranial nerves, and, according to some anatomists, from the sympathetic, are described as entering the dura mater.

Glandulæ Pacchioni.—Upon the external surface of the dura mater, in the vicinity of the longitudinal sinus, are seen numerous small granular-looking elevations, generally collected into clusters, named glands of Pacchioni. The inner surface of the calvarium is marked by little pits, which receive these eminences. Similar excrescences are seen on the internal surface of the dura mater, and also upon the pia mater on each side of the longitudinal sinus: moreover, some project into that sinus itself.

It seems probable that these small bodies are originally developed

from the pia mater, and extend themselves through the dura mater to the external surface, causing a partial absorption or separation of the fibres of that membrane. In like manner, those seen in the longitudinal sinus seem to have perforated the dura mater, carrying before them a covering of the venous lining membrane. They consist, according to Valentin, of exudation corpuscles, and, in an older or more advanced condition, are composed of fibres. The cerebral layer of the arachnoid in the neighbourhood of these growths is usually thickened and opaque, and often adheres to the parietal portion.

These bodies are not found at birth; and according to the brothers Wenzel, exist in very small number, if at all, under the third year. Beyond the seventh year they are usually found, and they increase in number greatly as life advances; in some cases, however, they are altogether wanting. In animals there appears to be no corresponding structure.

Similar bodies are often found attached to the choroid plexuses of the fourth ventricle.

From all the circumstances of their history, these so-called glands of Pacchioni have been regarded by many as the result of a chronic action, producing an unnatural deposit in this situation. They are certainly not glandular in their nature.

THE PIA MATER.

The *pia mater* is a delicate cellulo-vascular membrane, richly supplied with vessels, which immediately invests the brain and spinal cord.

Upon the hemispheres of the brain, it is applied to the entire cortical surface of the convolutions, and dips into all the sulci. From its internal surface a multitude of small vessels enter the gray matter, and extend for some distance perpendicularly into the substance of the brain. This inner surface of the cerebral pia mater is on this account very flocculent, and is named *tomentum cerebri.* On the cerebellum a similar arrangement exists, but the membrane is finer and the vessels from its inner surface are not so long. The pia mater is also prolonged into the ventricles, and there forms the velum interpositum and choroid plexuses.

Structure.—It consists of interlaced bundles of cellular tissue, conveying great numbers of blood-vessels; and, indeed, its peculiar office, both on the brain and spinal cord, seems to be that of providing a nidus or matrix for the support of the blood-vessels, as these are subdivided before they enter the nervous substance. According to Fohmann and Arnold it contains numerous lymphatic vessels.

On the spinal cord the pia mater has a very different structure from that which it presents on the encephalon, so that it has even been described by some as a different membrane under the name *neurilemma of the cord.* It is thicker, firmer, less vascular, and more adherent to the subjacent nervous matter: its greater strength is owing to its containing fibrous tissue, which is arranged in longitudinal shining bundles. A process of this membrane dips down into the anterior fissure of the cord, and serves to conduct blood-vessels into that part. At the roots

of the nerves, both in the spine and in the cranium, the pia mater becomes continuous with their neurilemma.

Towards the upper part of the cord, the pia mater presents a grayish mottled appearance, which is owing to pigment particles deposited within its tissue.

THE ARACHNOID MEMBRANE.

The *arachnoid* is a very fine, delicate, serous membrane, which, like other membranes of that class, forms a shut sac and consists of two portions, viz., a visceral (or cerebral) and a parietal layer.

The *parietal* layer, as already said, adheres to the dura mater of the brain and spinal cord,—the adhesion of one membrane to the other being most intimate.

The *visceral* portion passes over the various eminences and depressions on the cerebrum and cerebellum, without dipping into the sulci and smaller fissures; nor is it uniformly and closely adherent to the pia mater. The interval left between these two membranes is named generally the subarachnoid space.

This *subarachnoid space* is wider and more evident in some positions than in others. Thus,—in the longitudinal fissure, the arachnoid does not descend to the bottom, but passes across, immediately below the edge of the falx, at a little distance above the corpus callosum. In the interval thus left, the arteries of the corpus callosum run backwards along that body. At the *base* of the brain and in the *spinal canal* there is a wide interval between the arachnoid and the pia mater. In the former situation, this subarachnoid space extends over the pons and the interpeduncular space as far forwards as the optic nerves: around the cord, this space is also of considerable extent.

A certain quantity of *fluid* is contained within the proper sac of the arachnoid; but it has been shown by Magendie that the chief part of the cerebro-spinal fluid is lodged under the arachnoid, in the subarachnoid space, which usually communicates by an opening at the point of the fourth ventricle with the general ventricular cavity, as elsewhere stated. (Fig. 332, *z*.)

Magendie also pointed out the existence of a sort of septum dividing the spinal subarachnoid space at the back of the cord. This is a thin membranous partition, which passes in the median plane from the pia mater covering the posterior median fissure of the cord to the opposite part of the loose portion of the arachnoid membrane. It is incomplete and cribriform; and consists of bundles of white fibres interlaced more or less with one another. Fibrous bands of the same texture pass across the subarachnoid space in various situations both within the spinal canal and at the base of the brain, stretching thus from the arachnoid to the pia mater.*

* I was at one time disposed to think that the subarachnoid space was lined throughout by a delicate serous membrane, and that the septum above described consisted of a duplicature of this membrane, extending from the loose arachnoid to the cord, as the mesentery passes to the intestine. I was led to entertain this idea, on considering that the space in question contains fluid; that the loose portion of the arachnoid is separable, in many parts, into two layers; and that a thin membrane can be raised from the surface of the ligamentum denticulatum and the roots of the nerves, as they pass across the space. I

As the cerebral and spinal nerves proceed to their foramina of exit from the cranium and vertebral canal, they are loosely surrounded by tubular sheaths of the arachnoid membrane, which extend along each nerve from the visceral to the parietal layer.

Structure.—When examined under the microscope, the arachnoid is found to consist of bundles of fibres like those of fibrous tissue, interlaced with one another. A simple layer of scaly epithelium can be demonstrated on various parts of its free surface, and probably exists all over.

Cerebro-spinal fluid.—This is a very limpid serous fluid, which occupies the subarachnoid space. When collected immediately after death, its quantity was found by Magendie in the human subject to vary from two drachms to two ounces. It is slightly alkaline, and consists, according to an analysis by Lassaigne, of 98·5 parts of water, the remaining 1·5 per cent. being solid matter, animal and saline. In experiments made on the dog, it was found by Magendie to be reproduced in thirty-six hours, after it had been drawn off by puncturing the membrane at the lower part of the cord.

Its chief use is probably mechanical, there being obvious advantages in the delicate structures placed within the cranium and spine being surrounded by a fluid medium. As just now stated, it is rapidly secreted, and perhaps it is also as readily absorbed; and thus, being easily susceptible of changes in its quantity, it may, in this way, admit of variations in the amount of blood circulating in the vessels of the brain and spinal cord, although the cranio-vertebral cavity in which they are lodged does not vary in its capacity.

Ligamentum denticulatum.—This is a narrow fibrous band which runs along each side of the spinal cord in the subarachnoid space, between the anterior and posterior roots of the nerves, commencing above at the foramen magnum and reaching down to the lower pointed end of the cord. By its inner edge this band is connected with the pia mater of the cord. Its outer margin is widely scolloped or serrated, and the points of its serratures or denticulations are attached, in the intervals between the nerves, to the inner surface of the dura mater, being covered at their insertion by the arachnoid membrane. The first or highest denticulation is fixed opposite the margin of the foramen magnum, between the occipital artery and the hypoglossal nerve; and the others follow in order, alternating with the successive pairs of spinal nerves. In all, there are about twenty-two of these points of insertion. At the lower end, the ligamentum denticulatum is continued into the terminal filament of the spinal cord, which thus connects it to the dura mater at the lower end of the sheath, and might, therefore, although much longer, be compared with its lateral denticulations.

Structure.—It consists of white fibrous tissue, mixed with many exceedingly fine elastic fibres, seen on applying acetic acid. It is obviously continuous on the one hand with the fibrous tissue of the pia mater, and with that of the dura mater on the other.

The use of the ligamentum denticulatum is obviously to support the cord and its nerves.

The pia mater of the cord presents a conspicuous fibrous band,

have since found, however, that this view will not stand the test of microscopic scrutiny: for the internal layer has not the defined surface of a serous membrane, but is composed of openly-reticulated bundles of filaments, like cellular tissue.—W. S.

running down in front over the anterior median fissure. This was named by Haller, *linea splendens.*

BLOOD-VESSELS OF THE BRAIN AND SPINAL CORD.

The arteries of the brain and in part those of the spinal cord are derived from the internal carotid and vertebral arteries. These vessels having passed across the arachnoid cavity, get into the subarachnoid space and then divide and subdivide into branches, which, in their further course to the nervous centres, are supported by the pia mater, and, it may be remarked, are more deeply placed in the various fissures and sulci than the small veins, which do not accompany the arteries, but pursue a different course and are seen upon the surface of the pia mater.

Moreover, it is also to be observed, that whilst the main branches of the arteries are situated at the base of the brain, the principal veins tend towards the upper surface of the hemispheres, where they enter the superior and inferior longitudinal sinuses: the veins of Galen, however, coming from the lateral ventricles and choroid plexuses, run backwards to the straight sinus.

DEVELOPMENT OF THE BRAIN AND SPINAL CORD.

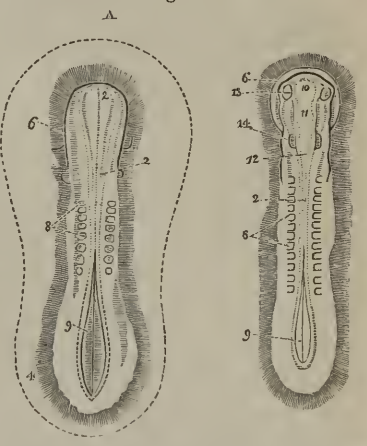
The cerebro-spinal axis, with the cranio-vertebral cavity surrounding it, is the part of the embryo which first begins to be formed. It commences in the external or serous layer of that portion of the ovum which has been named the blastoderma or germinal membrane, in form of a *groove* dilated at one extremity, and bounded by two ridges named the *dorsal plates* (laminæ dorsales). See fig. 349, and description of that figure.

On each side of the groove, near its middle, the small quadrangular rudiments of the vertebræ, fig. 349,[8] begin to appear in the substance of the dorsal plates; while a thin portion of each dorsal plate next the groove is destined to form, along with its fellow of the opposite side, the rudiments of the cerebro-spinal axis.

In the progress of development, the dorsal plates unite over the groove, at first in the middle and then at the extremities, and thus convert it into a canal, in which the commencing brain and spinal cord may soon be discovered. The enlarged or cephalic end, A,[2], of this *cranio-vertebral* canal, as it might be named, is dilated into three vesicles, B,[10],[11],[12], which afterwards form the cranial cavity, and in which the encephalon is developed; whilst the remaining part of the canal (the vertebral part) ultimately contains the spinal cord.

The matter of which the cerebro-spinal axis is at first composed soon separates, according to Baër, into an external layer, which forms its membranous envelopes,

Fig. 349.



Shows the early condition of the nervous centres in the embryo of the fowl—(Reichert). A. The sides of the groove have united in a great extent, and converted it into a canal; the dilated cephalic extremity is seen at 2; from 2 to 9 is the groove partly closed; 9 is the open part at the lower end, which remains afterwards as the rhomboidal sinus. 8. Rudiments of the vertebræ. — B. The groove is closed except at 9—the rhomboidal sinus. 8. Plates of vertebræ. 10. Anterior or first vesicle; 11, second or middle; and 12, third or posterior vesicle.

and an internal tubular portion, which afterwards becomes the proper nervous substance.

DEVELOPMENT OF THE SPINAL CORD.

The *spinal cord*, formed, as already stated, by the union of two lamellæ derived from the inner surface of the dorsal plates, is at first a groove open in its whole length on the dorsal aspect; but the edges of this groove soon meet, so as to form a medullary tube. At the ninth week, Tiedemann* has seen the borders of this groove still apart; at the twelfth they were in close contact, so as to form a sort of tube, but they could be easily separated from one another. The perfect closing of this groove is delayed towards the lower end of the cord, which is slightly enlarged, and presents a longitudinal median slit, analogous to the rhomboidal sinus in birds.—Fig. 349, [9] [9].

The central cavity of the medullary tube formed by the closure of the groove, is gradually narrowed by the thickening of the two halves of the cord and by the deposition of gray matter, and at last is obliterated in the human species throughout its entire length, except for about half an inch below the fourth ventricle. In many animals, however, it is persistent throughout life.

The *anterior fissure* of the cord is developed very early, and contains even at first a process of the pia mater.

The *cervical* and *lumbar enlargements*, opposite the attachments of the brachial and crural nerves, appear at the end of the third month: in these situations the central canal, at that time not filled up, is somewhat larger than elsewhere.

At first the cord occupies the whole length of the vertebral canal, so that there is no cauda equina. At the beginning of the fourth month, the vertebræ having grown faster than the cord, the latter seems as it were to have retired up into the canal, and the *cauda equina* is commenced. At the ninth month, the lower end of the cord is opposite the third lumbar vertebra.

DEVELOPMENT OF THE ENCEPHALON.

The three cephalic dilatations of the primitive cranio-vertebral cavity, fig. 349, B, [11], [11], [12], contain *three* hollow *vesicles* of nervous matter, which are the rudiments of the future encephalon.

The anterior or *first vesicle* soon becomes divided into an anterior and a posterior portion. The anterior portion forms the principal mass of the hemispheres, fig. 350, A [6], with the corpora striata, [7]; whilst the posterior portion, [5], is developed into the thalami and third ventricle.

The *second* or middle vesicle, [4], forms the corpora quadrigemina above, and the crura cerebri below,—its cavity remaining as the Sylvian aqueduct.

The *third* or posterior vesicle, [3] to [2], continues incomplete above for some time, as far as nervous substance is concerned. At length its anterior portion, [3], is closed over and forms the cerebellum above, whilst on its under surface the pons Varolii appears. The posterior portion, on the other hand, [2], continues open on its dorsal aspect, and forms the medulla oblongata and fourth ventricle.

These three vesicles, at first arranged in a straight line, one before the other, soon alter their position, in correspondence with the curving downwards of the cephalic end of the embryo. Thus at the seventh week, as figured by Tiedemann, there is an angular bend forwards between the hindmost vesicle and the rudimentary spinal cord, [1],—the projecting angle (backwards) being named the cervical tuberosity, [2]. Another bend, but in the opposite direction, exists between that part of the third vesicle which forms the medulla oblongata, and that which gives rise to the cerebellum, [3]. Lastly, a third angle is produced by a bend forwards and downwards in the region of the middle vesicle, [4], from which the corpora quadrigemina are developed, and which forms, at this period, the highest part of the encephalon; whilst the anterior or first vesicle, [5], [6], [7], is bent nearly at a right angle downwards.

* To save the repetition of references, it may be stated here, that the description of the successive changes of development in the spinal cord and brain, and the periods at which they occur, are taken from Tiedemann's account. Anatomie und Bildungsgeschichte des Gehirns. Nürnberg, 1816.

At a later period of development, this first vesicle, which, as stated above, represents the cerebral hemispheres, increases greatly in size upwards and backwards, and gradually covers first the thalami, then the corpora quadrigemina, and lastly the cerebellum.

On laying open the rudimentary encephalon, two tracts of nervous matter are seen to be prolonged upwards from the spinal cord upon the floor of the cephalic vesicles: these tracts, which are doubtless connected with the anterior and lateral parts of the cord, are the rudiments of the *crura* cerebri and corresponding columns of the medulla oblongata.

Fig. 350.

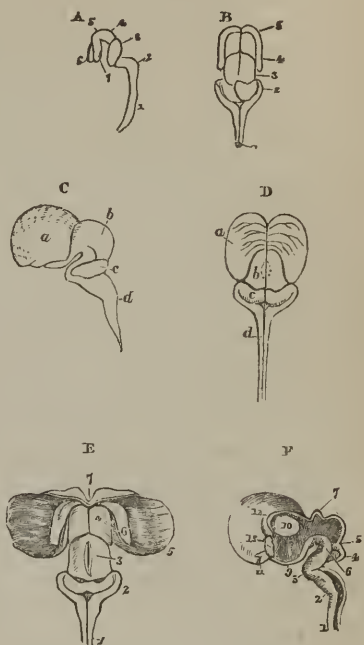


Fig. 350.—These figures show the early form of the brain and spinal cord in the human embryo (Tiedemann).—A. At the seventh week, viewed from the side. 1. Spinal cord. 2 to 3 is the third vesicle; 4, the middle vesicle; 5,6,7, the first or anterior vesicle. 2, is on the hind part of medulla, or the cervical tuberosity. 3. The cerebellum. 4. Corpora quadrigemina. 5. Optic thalami. 6. Cerebral hemisphere. 7. Corpus striatum.—B. At the ninth week, seen from behind. 1. Spinal cord and medulla oblongata, open behind. 2. Cerebellum. 3. Corpora quadrigemina. 4. Thalami, still uncovered. 5. Right and left hemispheres, now very thin. —C, D. At the twelfth week, side and back views. *a.* Cerebrum. *b.* Corpora quadrigemina. *c.* Cerebellum. *d.* Medulla oblongata. N.B. The thalami at this period are covered by the cerebral hemispheres.—E, F. At the twelfth week: in E, which is seen from behind, the hemispheres are reflected outwards. 1. Cord and medulla oblongata. 2. Cerebellum. 3. Corpora quadrigemina. 4. Thalami, which are here uncovered by the reflection of the hemispheres. 5, 6. The right corpus striatum, embedded in the hemispheres. 7. The point of commencement of corpus callosum. F. Is a vertical median section, showing the cavity from the cord up to the third ventricle. 1, 2. Spinal cord and medulla, still hollow. 3. Bend at which pons Varolii is to be formed. 4. Cerebellum. 5. Lamina (superior peduncles) leading up to corpora quadrigemina. 6. Crura cerebri. 7. Corpora quadrigemina. 8. Third ventricle. 9. Infundibulum. 10. Thalamus, now solid. 11. Optic nerves. 12. Cleft leading into lateral ventricle. 13. Commencing corpus callosum.

FURTHER DEVELOPMENT OF THE PRIMARY VESICLES.

The *third vesicle.*—The posterior portion of this vesicle, corresponding with the *medulla oblongata,* is never closed above by nervous matter. The open part of the medullary tube constitutes the floor of the *fourth ventricle,* which communicates below with the canal of the spinal cord, and eventually forms the calamus scriptorius.

The three elements of the medulla oblongata begin to be distinguished about the third month; first, the *restiform* bodies, which are connected with the commencing cerebellum, and afterwards the anterior pyramids and olives. The *anterior pyramids* become prominent on the surface and distinctly defined in the fifth month; and by this time also their decussation is evident. The *olivary* fasciculi are early distinguishable, but the proper *olivary body,* or tubercle, does not appear till about the sixth month. The *fasciolæ cinereæ* of the fourth ventricle can be seen at the fourth or fifth month, but the *white striæ* not until after birth.

The anterior part of the third vesicle is soon closed above by nervous substance, and forms the commencing *cerebellum,* A, 3. This part exists, B, 2, about

the end of the second month, as a delicate medullary lamina, forming an arch behind the corpora quadrigemina across the widely-open primitive medullary tube.

According to Bischoff, the cerebellum does not commence by two lateral plates which grow up and meet each other in the middle line; but a continuous deposit of nervous substance takes place across this part of the medullary tube, and closes it in at once. This layer of nervous matter, which is soon connected with the corpora restiformia, or inferior peduncles, increases gradually up to the fourth month (see C, D, *c*, also E, [2]), at which time there may be seen on its under surface the commencing *corpus dentatum:* in the fifth month, a division into five *lobes* has taken place; at the sixth, these lobes send out *folia*, which are at first simple, but afterwards become subdivided. Moreover, the *hemispheres* of the cerebellum are now relatively larger than its median portion, or *worm*. In the seventh month the organ is more complete, and the *flocculus* and *posterior velum*, with the other parts of the inferior vermiform process, are now distinguishable, except the *amygdalæ*, which are later in their appearance.

Of the *peduncles* of the cerebellum, the *inferior* pair (corp. restiformia) are the first seen—viz., about the third month; the *middle* peduncles are perceptible in the fourth mouth; and at the fifth, the *superior* peduncles and the Vieussenian valve, F [5]. The *pons Varolii* is formed, as it were, by the fibres from the hemispheres of the cerebellum, embracing the pyramidal and olivary fasciculi of the medulla oblongata. According to Baer, the bend which takes place at this part of the encephalon—just over [7], A, also at [8] F—thrusts down a mass of nervous substance before any fibres can be seen; and in this substance transverse fibres, continuous with those of the cerebellum, are afterwards developed. From its relation to the cerebellar hemispheres, the pons keeps pace with them in its growth; and, in conformity with this, its transverse fibres are few, or entirely wanting in those animals in which there is a corresponding deficiency or absence of the lateral parts of the cerebellum.

The *second or middle vesicle.*—The *corpora quadrigemina*—A,[4], B and E,[3]; C and D, *b*—are formed in the upper part of the middle cephalic vesicle, A, [4]; the hollow in the interior of which, shown in D, communicates with those of the first and third vesicles. The corpora quadrigemina, in the early condition of the human embryo, are of great proportionate volume, in harmony with what is seen in the lower vertebrata, but subsequently they do not grow so fast as the anterior parts of the encephalon, and are therefore soon reached by the cerebral hemispheres, which at the sixth month cover them in completely. Moreover, they become gradually solid, by the deposition of matter within them; and as, in the mean time, the *cerebral peduncles*, D,[6], are growing rapidly in size in the floor of this second cephalic vesicle, the cavity in its interior is quickly filled up, with the exception of the narrow passage named the *Sylvian aqueduct*. The fillet is distinguishable in the fourth month. The corpora quadrigemina of the two sides are not marked off from each other by a vertical median groove until about the sixth month; and the transverse depression separating the anterior and posterior pairs is first seen about the seventh month of intra-uterine life.

The *first* or anterior *vesicle*, A,[5],[6],[7].—This vesicle, as already stated, is divided into two portions—viz., a posterior, which is developed into the optic thalami and third ventricle, and an anterior, which forms the principal mass of the cerebral hemispheres, including the corpora striata.

a. The two *optic thalami*—A,[5] B and C,[4]—consist, therefore, at first of a single hollow sac of nervous matter, the cavity of which communicates in front with the interior of the commencing cerebral hemispheres, and behind with that of the middle cephalic vesicle (corpora quadrigemina). Soon, however, by means of a deposit taking place in their interior, behind, below, and at the sides, the thalami become solid, F,[14], and at the same time a cleft or fissure appears between them above, and penetrates down to the internal cavity, which continues open at the back part opposite the entrance of the Sylvian aqueduct. This cleft, or fissure, is the *third ventricle*. Behind, the two thalami continue united by the *posterior commissure*, which is distinguishable about the end of the third month, and also by the *peduncles of the pineal gland*. The *soft commissure* could not be detected by

Tiedemann until the ninth month; but its apparent absence at earlier dates may perhaps be attributed to the effects of laceration.

At an early period the *optic tracts* may be recognised as hollow prolongations from the outer part of the wall of the then vesicular thalami. At the fourth month these tracts are distinctly formed.

The *pineal gland*, according to Baer, is developed from the back part of the thalami, where those bodies continue joined together; but it is suggested by Bischoff that its development may be rather connected with the pia mater. It was not seen by Tiedemann until the fourth month: subsequently, its growth is very slow; and it at first contains no gritty deposit, which, however, was found by Sœmmerring at birth.

The *tuber cinereum* may be recognised on the under surface of the first vesicle before the third month, according to Valentin, who thinks that its development is connected with that of the corpora albicantia.

The *infundibulum*, E,[9], appears at a very early period, extending from the lower part of the anterior cephalic vesicle into a depression in the base of the rudimentary cranium. It is thought by Baer to be the anterior extremity of the primitive medullary tube.

Rathké asserts, on the ground of observations recently made, that the first condition of the *pituitary body* is that of a small sac or pouch derived from the mucous membrane of the pharynx, which is prolonged upwards into the base of the cranium, in the form of a cul de sac, and reaches the point of the infundibulum. This sac is afterwards shut off from the pharyngeal cavity, and the closed vesicle thus formed becomes attached to the infundibulum, and constitutes the pituitary body. Reichert, on the other hand, regards this body as the remains of the anterior extremity of the corda dorsalis. Tiedemann describes it as a large soft mass at the end of the third month.

b. The *corpora striata*, which, with the rest of the cerebral hemispheres, are evolved from the anterior portion of the first cephalic vesicle, at [7], A, appear as two dark masses rising up from the floor of that part of the vesicle, one on each side. Unlike the thalami, the corpora striata, E,[6] are always concealed, being included from the first in the vesicular cerebral hemispheres, into the cavity of which they soon project from the outer side and from below.

The right and left *cerebral hemispheres*, which at first are proportionately small, appear as two little hollow vesicles, A,[6], which bud out, one on each side, from the fore part of the anterior primary cephalic vesicle; and as these go on growing laterally, a longitudinal median depression is soon formed between them, B,[5]. Continuing to remain hollow, but yet enlarging, and having their walls increased in thickness, the hemispheres form, during the fourth month (Tiedemann), two smooth shell-like lamellæ, C and D, *a*, which include the cavities afterwards named the *lateral ventricles*, and the parts contained within them. Following out the subsequent changes affecting the exterior of the cerebral hemispheres, it is found that about the fourth month the first traces of some of the *convolutions* appear, the intermediate *sulci* commencing only as very slight depressions on the hitherto smooth surface. Though the hemispheres continue to grow quickly upwards and backwards, the convolutions become distinct by comparatively slow degrees at first; but towards the seventh and eighth months they are developed with great rapidity, and at the beginning of the last month of intra-uterine life appear to be completely formed.

The *Sylvian fissure*, which afterwards separates the anterior from the middle lobe of each hemisphere, begins as a very slight depression between them about the fourth month.

From the earliest period the hemispheres, E,[5], conceal the corpora striata,[6]; by the end of the third month they have extended so far backwards as to have covered the thalami, E,[4], F,[10]; at the fourth, they reach the corpora quadrigemina; at the sixth, they cover those bodies and great part of the cerebellum, beyond which they project backwards by the end of the seventh month.

Between and within the hemispheres other changes take place. At first there is no corpus callosum, and no fornix; nor is there any separation of the common internal cavity into two lateral cavities or ventricles.

According to Tiedemann, the *corpus callosum*, which certainly commences in

front, is first seen about the end of the third month, as a narrow vertical band or commissure—E,[7] F,[13]—extending across between the fore part of the two hemispheres. Subsequently it becomes horizontal, and grows backwards together with the hemispheres, until it completely covers the optic thalami. Tiedemann considers that it results from the junction across the median plane of the radiating fibres of the hemispheres. In the same way, he supposes that the *anterior commissure*, which is seen during the third month, is formed by the union of other peduncular fibres, which have passed through the corpora striata.

Bischoff, however, is of opinion that the corpus callosum has its origin in the part of the anterior primitive vesicle, situated between the rudimentary hemispheres, where these continue united together in front, at the bottom of the median longitudinal depression which is formed between them. From this point, he describes it as extending backwards over the thalami.

The *fornix*, like the corpus callosum, appears to be formed in conjunction with the hemispheres. According to Bischoff, its anterior pillars begin near the same point as the commencing corpus callosum, but of course behind it: whilst the body and posterior pillars are formed upon the internal and posterior borders of the growing hemispheres. The fornix certainly commences in front, like the corpus callosum. Burdach says its anterior pillars are seen about the same time as the rudiments of this latter body (second month); but Tiedemann and Valentin place the period at the end of the third month,—the *corpora albicantia* having appeared a little earlier, at first as a single mass. The posterior pillars are not seen until the fourth or fifth month. Their free border forms the *corpus fimbriatum* on each side, and their enlarged extremity appears then to constitute the commencing *pes hippocampi*, the indentations upon which, however, are not evident until the ninth month. The *hippocampus minor* appears at the end of the fourth month, as a folding inwards of the hemisphere into the ventricular cavity.

In the course of development, the fore part of the fornix separates from the under surface of the corpus callosum, leaving two thin vertical lamellæ, which form the *septum lucidum*, and the intermediate fifth ventricle. At first, this ventricle communicates with the cavity of the third ventricle below, but it is afterwards completely occluded by the union of the two lamellæ. The septum and fifth ventricle are recognised only about the fifth month.

In the first instance, the vesicular cerebral hemispheres enclose a common cavity; but as the median longitudinal depression is formed between them, as the corpus callosum and fornix are developed from before backwards, and as the septum lucidum descends from one to the other in the median plane, this single cavity is divided into the two *lateral ventricles*, which after a time communicate with each other, and with the third ventricle, by a narrow slit, F,[12]; and, finally, only by the foramen of Monro. The form of each ventricular cavity depends upon that of the several parts which project into it. Thus its *anterior cornu* is produced around the anterior extremity of the corpus striatum, and its *descending cornu* behind the thalamus and below the striated body. The *posterior cornu* is later in its appearance, and is developed in the substance of the posterior lobe, as that extends itself backwards. The lateral ventricles, or rather the parts of which their walls are composed, do not acquire their characteristic forms until the eighth or ninth month.

GRAY AND WHITE SUBSTANCE OF THE NERVOUS CENTRES.

The distinction between the gray and white substances is not at first to be made out; but there is no evidence to show that one precedes the other in its formation. Valentin states that he has distinguished the one from the other at the third month: less from the difference in their colour than from their microscopic characters.

MEMBRANES OF THE ENCEPHALON.

It is remarked by Bischoff, that the membranes of the brain are everywhere formed by the separation of the outer layer of the primitive cephalic mass; and thus, that the *pia mater* does not send inwards processes into the fissures or sulci, or into the ventricular cavities; but that every part of this vascular membrane,

including the *choroid plexuses* and *velum interpositum*, is formed in its proper position upon the nervous matter.

The pia mater and dura mater have both been detected about the seventh or eighth week, at which period the tentorium cerebelli existed. At the third month, the falx cerebri, with the longitudinal and lateral sinuses, could be made out; and the choroid plexuses of both the lateral and fourth ventricles were distinguishable. No trace of arachnoid, however, could be seen until the fifth month.

CRANIAL NERVES.

All nerves issuing from the cerebro-spinal centre which are transmitted through apertures in the base of the skull, are included in the class of *cranial nerves.*

These nerves are named numerically, according to the relative position of the apertures for their transmission through the cranium; and they are likewise distinguished by other names, taken chiefly from the organs or parts to which they are distributed (*e. g.* facial, glosso-pharyngeal), or from the functions to which they minister (olfactory, optic, &c.)

The number of the cranial nerves is differently stated by anatomists. The difference is mainly owing to the circumstance, that under one system the nerves which enter the internal auditory meatus, and those which pass through the jugular foramen, are in each case considered a single pair (seventh and eighth) divisible into parts; while under another system each of the nerves is numbered separately. The classifications exemplifying the two modes of numbering—those of Willis and Sœmmerring—are subjoined:—

WILLIS.

First pair of nerves,		Olfactory nerves.
Second "		Optic.
Third "		Oculo-motor.
Fourth "		Pathetic.
Fifth "		Trifacial or trigeminal.
Sixth "		Abducent-ocular.
Seventh	nervus durus,	Facial.
	n. mollis,	Auditory.
Eighth	n. vagus,*	Pneumogastric.
	n. accessorius,	Spinal accessory.
Ninth "		Lingual or hypoglossal.
Tenth "		Suboccipital.

SŒMMERRING.

The first six names are the same as those of Willis.

Seventh pair of nerves,	Facial nerves.
Eighth "	Auditory.
Ninth "	Glosso-pharyngeal.
Tenth "	Pneumogastric.
Eleventh "	Spinal accessory.
Twelfth "	Lingual or hypoglossal.

The arrangement of Sœmmerring is the preferable one, as being the simplest and most natural; for each of the parts included in the seventh and eighth pairs of Willis is really a distinct nerve. But as the plan of Willis is in general use, it will most conveniently be fol-

* Willis described the glosso-pharyngeal nerve as a branch of the vagus.

lowed here: with the exception, however, that the tenth pair (sub-occipital) of that anatomist will be ranged with the spinal nerves. The cranial nerves will therefore be regarded as consisting of nine pairs.

It may be mentioned that some anatomists, looking to the resemblance between the bones of the skull and the vertebræ of the spinal column, have endeavoured to show an analogy between the nerves also. Accordingly, cranial nerves which possess ganglia, and others devoid of ganglia, have been grouped together, so as to form compound nerves, named cranio-vertebral; and thus regarded, they have been looked upon as analogous to spinal or (according to the language of this system) spini-vertebral nerves. The arrangement suggested by Professor Müller will illustrate this mode of viewing the cranial nerves:—

1. The first cranio-vertebral nerve is composed of the fifth, third, fourth, sixth (and facial?) nerves.

2. In the second cranio-vertebral nerve are included the pneumogastric, glosso-pharyngeal, and spinal accessory nerve.

3. The hypoglossal is the third cranio-vertebral nerve.

OLFACTORY NERVE.

The olfactory or first cranial nerve (nervus olfactorius, par primum), the special nerve of the sense of smelling, is distributed exclusively to the nasal fossæ. The course of this nerve within the cranium has been already described (*ante*, page 243). It remains to add an account of the branches as they are distributed in the interior of the nose.

From the under surface of the olfactory bulb, fig. 355, [1], numerous branches proceed through the holes in the cribriform plate of the ethmoid bone, each being invested by tubular prolongations of the membranes of the brain. These tubes of membrane vary in the extent to which they are continued on the branches. Thus the offsets of the dura mater sheathe the filaments, and join the periosteum lining the nose; those of the pia mater become blended with the neurilemma of the nerves; and those of the arachnoid reascend to the serous lining of the skull.

The branches are arranged in three sets. The inner set, lodged for a while in grooves on the surface of the bone, ramify in the pituitary membrane of the septum; the outer set, fig. 355, extend to the upper two spongy bones, and the plane surface of bone in front of these; and the middle set, which are very short, are confined to the roof of the nose. The distribution of the olfactory nerves is confined to the nasal fossæ; none of the branches reach the lower spongy bones.—(See Anatomy of the Nose.)

OPTIC NERVE.

The optic or second cranial nerve (nervus opticus, par secundum), a nerve of special sense, belongs exclusively to the eye. The connexion of this nerve with the nervous centre, and the optic tract with the commissure of the nerves of opposite sides, have been described at a former part of this work (page 244).

From the commissure at the base of the brain, each nerve diverges from its fellow, becomes round and firm, and is incased in a neurilemma. In the orbit, which it enters by the optic foramen, it is in-

vested with a sheath of the dura mater, and surrounded by the recti muscles; and finally, after piercing successively the sclerotic and choroid coats at the back of the eyeball, it expands into the retina.—(See the Anatomy of the Eye.)

THIRD PAIR OF NERVES.

This nerve, the common motor nerve of the eyeball, (nerv. motorius oculi, par tertium,) fig. 351, [4], gives branches to five of the seven muscles of the orbit.

Like the other motor nerves, the third is round, firm, and white; it is invested from the first by a sheath of pia mater, and afterwards by a tube of the arachnoid membrane.

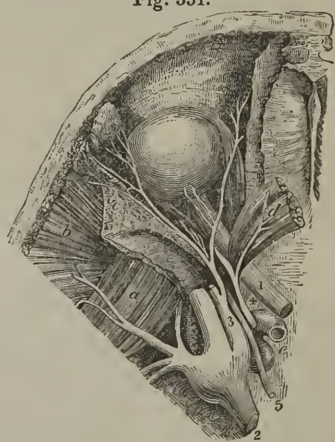
In its course to the orbit, this nerve is contained in the external fibrous boundary of the cavernous sinus with other nerves; and on entering the canal appropriated to it in the dura mater, the serous covering of the arachnoid is reflected from it.*

After receiving one or two delicate filaments from the cavernous plexus of the sympathetic, the third nerve divides near the orbit into two parts, which are continued into that cavity between the heads of the external rectus muscle.

Branches.—The *upper*, the smaller *division*, fig. 351, is directed inwards over the optic nerve to the rectus superior muscle of the eye, and the elevator of the eyelid, to both which muscles it furnishes offsets.

The *lower* and larger *division* of the nerve, fig. 354, separates into three branches; of which one reaches the inner rectus; another the lower rectus; and the third, the longest of the three, runs onward between the lower and the outer rectus, and terminates below the ball of the eye in the inferior oblique muscle. The last-mentioned branch is connected with the lower part of the lenticular ganglion by a short thick cord, and gives two filaments to the lower rectus muscle.

Fig. 351.



The deep nerves of the orbit seen from above by removing the bone and dividing the elevator of the upper eyelid and the upper rectus muscle. (From Arnold.) *a.* Internal pterygoid muscle. *b.* Temporal muscle. *c.* Cut surface of bone. *d.* Elevator of the eyelid and upper rectus muscle. *e.* Carotid artery. 1. Optic nerve. 2. Fifth nerve. 3. Ophthalmic nerve. 4. Third nerve. 5. Sixth nerve.

The several branches of the third nerve enter the muscles to which they are distributed, on that surface of the muscle, in each case, which looks towards the eyeball.

Position of certain nerves at the cavernous sinus, and as they enter the orbit.—As several nerves are placed close together at the cavernous sinus, and as they enter the orbit through the same foramen, a statement will now, once for all, be made respecting the position they bear

* For an account of the relative position of the orbital nerves before they enter the orbit, see the statement placed after description of this (the third) nerve.

one to the other, in order to save the repetition which otherwise would be necessary when each of the nerves in question is under consideration.

At the cavernous sinus.—In the dura mater which bounds the cavernous sinus on the outer side, the third and fourth nerves and the ophthalmic division of the fifth are placed, as regards one another, in their numerical order, both from above downwards and from without inwards. The sixth nerve is close to the carotid artery—not in the wall of the sinus. Near the sphenoidal fissure, through which they enter the orbit, the relative position of the nerves is changed, and their number is augmented, the sixth nerve being here close to the rest, and both the third and ophthalmic nerves being divided—the former into two, the latter into three parts.

In the sphenoidal fissure.—The fourth, and the frontal and lachrymal branches of the fifth, which are here higher than the rest, lie on the same level, the first-named being the nearest to the inner side; and these nerves enter the orbit above the muscles, fig. 352. In entering the same cavity, the remaining nerves pass between the heads of the outer rectus muscle: the upper division of the third being highest, the nasal branch of the fifth next, the lower division of the third beneath these, and the sixth below all.

FOURTH PAIR OF NERVES.

The fourth (pathetic nerve, nervus trochlearis, n. patheticus, par quartum), fig. 352, [4], is the smallest of the cranial nerves, and is distributed only to the upper oblique muscle of the orbit.*

Fig. 352.

The nerves in the orbit above the muscles, brought into view by removing the roof of the orbit and the periosteum (Arnold). 1. Fifth nerve. 2. Ophthalmic branch of same nerve. 3. Third nerve. 4. Fourth nerve. 5. Optic nerve. 6. Sixth nerve. *a.* Internal carotid artery.

From the remoteness of its place of origin, (see p. 245,) this nerve has a longer extent in the skull than any other cranial nerve. It has the same general course as the third in the wall of the cavernous sinus, and through the sphenoidal fissure. Before reaching the sinus, it is on a level with the margin of the tentorium cerebelli, by the side of the pons Varolii; and it enters an aperture in the free border of the tentorium, outside that for the third nerve, and near the posterior clinoid process. Continuing onwards through the outer wall of the cavernous sinus, the fourth nerve enters the orbit by the sphenoidal fissure, and above the muscles. Its position with reference to other nerves in this part of its course has been already referred to (*ante*, p. 261).

* This nerve receives its name from entering the dura mater in the base of the skull, next to the third.

While in its fibrous canal in the outer wall of the sinus, the fourth nerve is joined by filaments of the sympathetic, and not unfrequently is blended with the ophthalmic division of the fifth. Bidder states that some offsets are here given from it to the dura mater.*

In the orbit, fig. 352, [4], the fourth nerve inclines inwards above the muscles, and finally enters the orbital surface of the upper oblique muscle.

FIFTH PAIR OF NERVES.

The fifth, or trifacial nerve (nerv. trigeminus, nerf trifacial, par quintum), fig. 353, the largest cranial nerve, is somewhat analogous to the spinal nerves. It is a nerve of special sense (taste), and it imparts common sensibility (the sense of touch) to the face and the fore part of the head, as well as to the eye, the nose, the ear, and the mouth. This nerve, moreover, supplies motor filaments to the muscles of mastication.

The roots of the fifth nerve, after emerging from the surface of the encephalon (*ante*, p. 245), are directed forwards, side by side, to the

Fig. 353.

A plan of the branches of the fifth nerve, modified from a sketch by Sir C. Bell. *a.* Submaxillary gland, with the submaxillary ganglion above it. 1. Small root of the fifth nerve, which joins the lower maxillary division. 2. Larger root, with the Gasserian ganglion. 3. Ophthalmic nerve. 4. Upper maxillary nerve. 5. Lower maxillary nerve. 6. Chorda tympani. 7. Facial nerve.

* Three or more small filaments are described as extending in the tentorium as far as the lateral sinus, and one is figured as joining the sympathetic on the carotid artery.—*Neurologische Beobachtungen*, Von. Dr. F. H. Bidder, Dorpat, 1836.

middle fossa of the skull, through an aperture in the dura mater,* on the summit of the petrous part of the temporal bone. Here the larger root alters in appearance: its fibres diverge a little, and enter a semilunar body, the Gasserian ganglion; whilst the smaller root passes beneath the ganglion, without being united in any way to it, and joins outside the skull the lowest of the three divisions of the nerve which issue from the ganglion.

The *ganglion of the fifth nerve* or *Gasserian ganglion* (ganglion semilunare seu Gasserianum) occupies a depression on the upper part of the petrous portion of the temporal bone, near its point, and is crescentic in form, the convexity being turned forwards. On its inner side the ganglion is joined by filaments from the carotid plexus of the sympathetic nerve, and, according to some anatomists, it furnishes from its back part filaments to the dura mater.

From the fore part, or convex border of the Gasserian ganglion, proceed three large branches. The highest (first or ophthalmic division) enters the orbit; the second, the upper maxillary nerve, is continued forwards to the face, below the orbit; and the third, the lower maxillary nerve, is distributed chiefly to the ear, the tongue, the lower teeth, and the muscles of mastication. The first two divisions of the nerve, proceeding wholly from the ganglion, confer sensibility on the structures in which they ramify; but the last, in addition to that function, gives motor branches to the muscles referred to, the additional fibres being derived from the smaller root which is joined with this part of the nerve. The third division is therefore a compound nerve, for in it are combined motor and sensory fibres. This part of the fifth cranial nerve is therefore analogous to a spinal nerve; but with the difference, that while all the offsets of a spinal nerve are believed to partake of both motor and sensory fibres, only a portion of the lower maxillary nerve is so compounded, the motor root being joined, as already stated, with but a part of the fibres emanating from the ganglion.

A. OPHTHALMIC NERVE.

The ophthalmic nerve, or first division of the fifth nerve, (ramus quinti paris primus vel ophthalmicus,) fig. 353, [3], is the smallest of the three offsets from the Gasserian ganglion. It is a flat fasciculus, about an inch in length, and is directed upwards to the sphenoidal fissure, where it ends in branches which continue onwards through the orbit. In the skull this division of the fifth nerve is contained in the process of the dura mater bounding externally the cavernous sinus, and it is here joined by filaments from the cavernous plexus of the sympathetic; according to Arnold, it gives recurrent branches to the tentorium cerebelli.† The fourth nerve frequently communicates by a considerable branch with this nerve.

* [In more than half the subjects I have examined, I have observed a spiculum of bone in the doubled edge of dura mater forming the superior margin of the foramen, and crossing the latter like a bridge, apparently having for its object the removal of pressure of the superincumbent brain upon the fifth nerve as it passes over the summit of the petrous portion of the temporal bone.—J. L.]

† There is as much difference of statement among modern as among ancient authorities respecting nerves to the dura mater. Bidder delineates branches furnished to this mem-

Near the orbit the ophthalmic nerve furnishes from its inner side the nasal branch, and then divides into the frontal and lachrymal branches. These offsets are transmitted separately through the sphenoidal fissure, and are continued through the orbit (after supplying a few filaments to the eye) to the lachrymal gland, to the nose, the eyelids, and the muscles and integument of the forehead.

1. Lachrymal Branch.

The lachrymal branch, fig. 352, at its origin is external to the frontal, and is contained in a separate tube of dura mater. In the orbit it courses along the outer part, above the muscles, to the outer angle of the cavity. When near the lachrymal gland, the nerve has a connecting filament with the orbital branch of the upper maxillary nerve, and when lying in close apposition with the gland, it gives many filaments to this and to the conjunctiva. Finally, the lachrymal nerve penetrates the palpebral ligament, and ends in the upper eyelid, the terminal ramifications being joined by the facial nerve.*

2. Frontal Branch.

The frontal branch, fig. 352,[2] the largest offset of the ophthalmic, is, like the preceding nerve, above the muscles in the orbit, and occupies the middle of the cavity, being between the elevator of the upper eyelid and the periosteum. About midway between the base and summit of the orbit, the nerve divides into branches (supratrochlear and supraorbital), which, after emerging at the fore part of the orbit, supply the muscles and integument of the forehead and the upper eyelid.

a. The internal or *supratrochlear branch*, fig. 352, is prolonged to the point at which the pulley of the upper oblique muscle is fixed to the orbit. Here it gives downwards a filament of connexion to the infratrochlear branch of the nasal nerve, and issues from the cavity between the orbicular muscle of the lids and the bone. In this last position filaments are distributed to the upper eyelid. The nerve next pierces the orbicularis palpebrarum and occipito-frontalis muscles, furnishing offsets to these muscles and the corrugator supercilii, and after ascending on the forehead, ramifies in the integument.

b. The external or *supraorbital branch*, fig. 353, passes through the notch of the same name to the forehead, and ends in muscular, cutaneous, and pericranial branches; while in the notch, this nerve distributes filaments (*palpebral*) to the upper eyelid.

The *muscular branches* referred to, supply the corrugator of the eyebrow, the occipito-frontalis, and the orbicular muscle of the eyelids, and join the facial nerve in the last muscle. The *cutaneous nerves*, among which two (outer and inner) may be noticed as the principal branches, are placed at first beneath the occipito-frontalis. The outer one, the larger, perforates the tendinous expansion of the muscle, and ramifies in the scalp as far back as the lambdoidal suture. The inner branch reaches the surface sooner than the preceding nerve, and ends in the integument over the parietal bone. The *pericranial branches* arise from the

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brane from the fourth nerve. Arnold represents the nerves as coming from the ophthalmic division of the fifth. Purkinje supposes them to be derived from filaments of the sympathetic nerve that run along the meningeal arteries; and Valentin states that they emanate from the sympathetic on the carotid artery. Mr. Swan says that the sixth nerve "sends several filaments to the dura mater behind the Gasserian ganglion."

* In consequence of the junction which occurs between the ophthalmic division of the fifth and the fourth nerve, the lachrymal branch sometimes appears to be derived from both.—Mr. Swan considers this the usual condition of the lachrymal nerve.—*A Demonstration of the Nerves of the Human Body*, page 36. London, 1834.

cutaneous nerve beneath the muscle, and end in the pericranium covering the frontal and parietal bones.

3. Nasal Branch.

The nasal branch (r. oculo-nasalis), fig. 353, which is more deeply placed than either of the other branches of the ophthalmic nerve, occupies a place successively in the cavities of the orbit, the cranium, and the nose. In its circuitous course this nerve has many and varied connexions.

Separating from the first division of the fifth nerve in the wall of the cavernous sinus, the nasal nerve enters the orbit between the heads of the outer rectus. Within the orbit it inclines inwards over the optic nerve, beneath the elevator of the upper eyelid and the upper rectus muscle, to the inner wall of the cavity. In this oblique course across the orbit it furnishes a single filament to the lenticular ganglion, and two or three (ciliary) directly to the eyeball; and at the inner side of the cavity it gives off a considerable branch (infratrochlear), which leaves the orbit at its fore part. After furnishing these offsets, the nasal nerve enters the anterior of the two foramina in the inner wall of the orbit, and passing above the ethmoidal cells, appears for a short space in the cranium. Within the skull, the nerve lies in a groove on the edge of the cribriform plate of the ethmoid bone, by which it is conducted to a special aperture at the side of the crista galli. By that opening it is transmitted to the roof of the nasal fossa, where it ends in two branches, one of which (external nasal) reaches the integument of the side of the nose, and the other (internal nasal) ramifies in the pituitary membrane. The branches, which have been indicated as furnished by the nasal nerve, will now be referred to in detail.

a. The *branch to the lenticular ganglion* (radix longa ganglii ciliaris), fig. 353, very slender, and about half an inch long, arises generally between the heads of the rectus. This small branch is sometimes joined by a filament from the cavernous plexus of the sympathetic or from the upper division of the third nerve; it lies on the outer side of the optic nerve, and enters the upper and back part of the lenticular ganglion, constituting its long root.

b. The *long ciliary nerves*, fig. 354, two or three in number, are situate on the inner side of the optic nerve; they join one or more of the nerves from the lenticular ganglion, (short ciliary,) and after perforating the sclerotic coat of the eye, are continued between it and the choroid to the ciliary ligament and the iris.

c. The *infratrochlear branch*, fig. 353, runs forwards along the inner side of the orbit below the upper oblique muscle, and receives near the pulley of that muscle a filament of connexion from the supratrochlear nerve. The branch is then continued below the pulley (whence its name) to the inner angle of the eye, and ends in filaments which supply the orbicular muscle of the lids, the caruncula, and the lachrymal sac, as well as the integument of the eyelids and side of the nose.

In the cavity of the nose the nasal nerve ends by dividing into the following branches:—

d. The *branch to the nasal septum* (ramus septi) extends to the lower part of the partition between the nasal fossæ, supplying the pituitary membrane near the fore part of the septum.

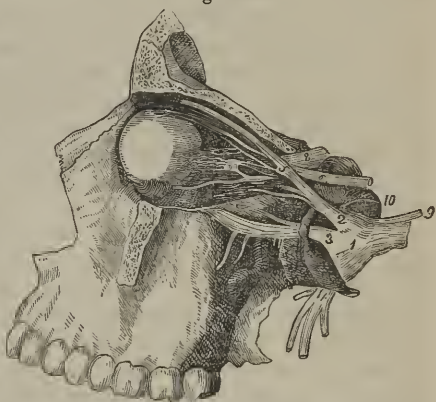
e. The *external branch* (r. externus seu lateralis), fig. 355,[2] descends in a groove on the inner surface of the nasal bone; and after leaving the nasal cavity between that bone and the lateral cartilage of the nose, fig. 353, it is directed downwards to the tip of the nose, beneath the compressor nasi muscle. While within the nasal fossa, this branch gives two or three filaments to the fore part of its outer wall, which extend as far as the lower spongy bone. The cutaneous part joins the facial nerve.

Summary.—The first division of the fifth nerve is altogether sensory in function. It furnishes branches to the ball of the eye and the lachrymal gland; to the mucous membrane of the nose and eyelids; to the integument of the nose and the fore part of the head; and to the muscles above the upper half of the circumference of the orbit. Some of the cutaneous filaments join offsets of the facial nerve, and the nerve itself communicates with the sympathetic.

OPHTHALMIC GANGLION.

There are four small ganglionic masses connected with the divisions of the fifth nerve: the ophthalmic ganglion with the first division, Meckel's ganglion with the second, and the otic and submaxillary ganglia with the third division of the nerve. These several bodies receive sensory nerves from the fifth, motor nerves from other sources, and twigs from the sympathetic; and the nerves thus joining the ganglia are named their roots.

Fig. 354.



A representation of some of the nerves of the orbit, especially to show the lenticular ganglion (Arnold). 1. Ganglion of the fifth. 2. Ophthalmic nerve. 3. Upper maxillary. 4. Lower maxillary. 5. Nasal branch, giving the *long root* to the lenticular ganglion. 6. Third nerve. 7. Inferior oblique branch of the third connected with the ganglion by the *short root.* 8. Optic nerve. 9. Sixth nerve. 10. Sympathetic on the carotid artery.

The *ophthalmic* or *lenticular* ganglion (gang. ophthalmicum, semilunare, vel ciliare), fig. 354, serves as a centre for the supply of nerves—motor, sensory, and sympathetic—to the eyeball. It is a small reddish body, situate at the back of the orbit, between the outer rectus muscle and the optic nerve, and generally in contact with the ophthalmic artery. Rounded, or somewhat quadrangular in shape, it is joined behind by offsets from the fifth, the third, and the sympathetic nerves; and from its fore part proceed ciliary nerves to the eyeball.—From the quantity of fat surrounding the ganglion, it is not always easy to detect it.

Union of the ganglion with nerves: its roots.—The border of the ganglion directed backwards receives three nerves. One of these, the *long root*, fig. 354, from the nasal branch of the ophthalmic trunk, joins the upper part (upper angle) of this border. Another branch, the *short root*, fig. 354, thicker and much shorter than the preceding, and sometimes divided into parts, is derived from the branch of

the third nerve supplied to the lower oblique muscle, and is connected with the lower part (lower angle) of the ganglion. The *third* small *nerve*, fig. 354, emanates from the cavernous plexus of the sympathetic, and reaches the ganglion with the long upper root; or these two nerves may be inseparably conjoined before reaching the ganglion.*

Branches of the ganglion.—From the fore part of the ganglion arise ten or twelve delicate filaments—the *short ciliary nerves*, fig. 354. These nerves are disposed in two fasciculi, arising from the upper and lower angles of the ganglion, and they run forwards, one set above, the other below the optic nerve, the latter being the more numerous. They are accompanied by filaments from the nasal nerve (long ciliary), with which some are joined. Having entered the eyeball by apertures in the back part of the sclerotic coat, the nerves are lodged in grooves on its inner surface; and at the ciliary ligament, which they pierce, (some few appearing to be lost in its substance,) they turn inwards and ramify in the iris.

B. UPPER MAXILLARY NERVE.

The upper maxillary nerve, or second division of the fifth cranial nerve (ramus quinti paris secundus, v. maxillaris superior), fig. 353,[4], is intermediate in size and situation between the ophthalmic and lower maxillary nerves.

This nerve, named from its connexion with the upper maxilla, has an almost horizontal direction, in great part through that bone, to the face. It commences at the middle of the Gasserian ganglion, presenting at its origin the appearance of a flattened band, and speedily leaves the skull by the foramen rotundum of the sphenoid bone, having previously become round and firm. After escaping from the cavity of the skull the nerve crosses the spheno-maxillary fossa, and enters the canal in the floor of the orbit (in the orbital plate of the upper maxilla), by which it is conducted to the face. As soon as it emerges from the infraorbital foramen, the upper maxillary nerve terminates beneath the elevator of the upper lip in branches which spread out to the side of the nose, the eyelid, and the upper lip.

Branches.—In the spheno-maxillary fossa a branch ascends from the upper maxillary nerve to the orbit, and one or two descend to join Meckel's ganglion, and to be distributed to the nose and mouth. Whilst the nerve is in contact with the upper maxilla, it furnishes dental branches—one on the tuberosity of the bone, the other at its fore part. To these must be added the terminal branches already indicated.

1. Orbital Branch.

The orbital or temporo-malar branch, a small cutaneous nerve, enters the orbit by the spheno-maxillary fissure, and divides into two branches (temporal and malar), which are distributed, as their names imply, to the temple and the prominent part of the cheek.

a. The *temporal branch* is contained in an osseous groove or canal in the outer wall of the orbit, and leaves this cavity by a foramen in the malar bone. When about to traverse the bone, it is joined by a communicating filament, (in some cases, two filaments,) from the lachrymal nerve. The nerve is then inclined upwards in the temporal fossa between the bone and the temporal muscle, perfo-

* Other roots have been assigned to the ganglion. See a paper by Valentin in Müller's Archiv for 1840.

rates the temporal aponeurosis an inch above the zygoma, and ends in cutaneous filaments over the temple. The cutaneous ramifications are united with the facial nerve, and sometimes with the superficial temporal nerve of the third division of the fifth.

b. The *malar branch* (r. subcutaneus malæ), lies at first in the loose fat in the lower angle of the orbit, and is continued to the face through a foramen in the malar bone, where it is frequently divided into two filaments. In the prominence of the cheek this nerve communicates with the facial nerve.

2. Spheno-palatine Branches.

The spheno-palatine branches, fig. 353, two in number, descending from the trunk of the nerve in the spheno-maxillary fossa, are connected with the ganglionic body (Meckel's ganglion), which is placed in that fossa, and are distributed to the nose and palate. These branches will be described with the ganglion referred to.—(See p. 270.)

3. Posterior Dental Branches.

The posterior dental branches, fig. 353, two in number, are directed outwards over the tuberosity of the maxillary bone.

a. One of the branches enters a canal in the bone by which it is conducted to the teeth, and gives forwards a communicating filament to the anterior dental nerve. It ends in filaments to the molar teeth and the lining membrane of the cavity in the upper maxillary bone, and near the teeth joins a second time with the anterior dental nerve.

b. The *anterior* of the two branches, lying on the surface of the bone, is distributed to the gums of the upper jaw and to the buccinator muscle.

4. Anterior Dental Branch.

The anterior dental branch, leaving the trunk of the nerve at a varying distance from its exit at the infraorbital foramen, enters a special canal in front of the antrum of Highmore. In this canal it receives the filament from the posterior dental nerve, and divides into two branches, which furnish offsets for the front teeth.

a. One branch, the *inner* one, supplies the incisor and canine teeth. Filaments from this nerve enter the lower meatus of the nose, and end in the membrane covering the lower spongy bone.

b. The *outer* branch gives filaments to the bicuspid teeth, and is connected with the posterior dental nerve.

5. Infraorbital Branches.

The infraorbital branches, fig. 353, which are large and numerous, spring from the end of the upper maxillary nerve beneath the elevator muscle of the upper lip, and are divisible into palpebral, nasal, and labial sets.

a. The *palpebral branch* (there may be two branches) turns upwards to the lower eyelid in a groove or canal in the bone, and supplies the orbicular muscle; it ends in filaments which are distributed to the lid in its entire breadth. At the outer angle of the eyelids this nerve is connected with the facial nerve.

b. The *nasal branches* are directed inwards to the muscles and integument of the side of the nose, and they communicate with the cutaneous branch of the nasal nerve furnished by the first division of the fifth nerve.

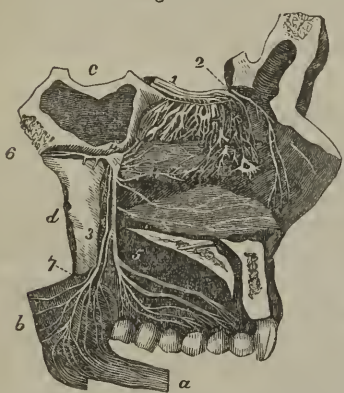
c. The *labial* branches, the largest of the terminal branches of the upper maxillary nerve, three or four in number, are continued downwards beneath the proper elevator of the upper lip. Branching out as they descend, these nerves are distributed to the integument, the mucous membrane of the mouth, the labial glands, and the muscles of the upper lip.

Near the orbit the infraorbital branches of the upper maxillary nerve are joined by branches of the facial nerve, the union between the two being named *infraorbital plexus.*

SPHENO-PALATINE GANGLION.

The spheno-palatine ganglion, commonly named Meckel's ganglion, fig. 355, has its seat on the spheno-palatine branches of the upper maxillary nerve, and is deeply placed in a hollow (spheno-maxillary fossa) between the pterygoid process of the sphenoid bone and the upper maxilla, and close to the spheno-palatine foramen. It is of a grayish colour, triangular in form or heart-shaped, and convex on the outer surface. The gray or ganglionic substance is not mixed with all the fibres of the spheno-palatine branches of the upper maxillary nerve, but is placed at the back part, at the point of junction of the sympathetic or deep branch of the vidian, so that the spheno-palatine nerves proceeding to the nose and palate pass to their destination without being involved in the ganglionic mass.

Fig. 355.



A view of the olfactory nerve, and of Meckel's ganglion seen from the inner side. (From Scarpa.) *a.* Elevator muscle of the soft palate thrown down. *b.* Part of the soft palate. *c.* Body of the sphenoid bone. *d.* Internal pterygoid plate. 1. Bulb of the olfactory nerve, giving branches over the upper two spongy bones. 2. Nasal branch of the ophthalmic nerve. 3. Smaller palatine nerve. 4. Meckel's ganglion. 5. Larger palatine nerve, dividing in the roof of the mouth. 6. Vidian nerve. 7. External palatine nerve.

Considering the ganglion as a centre from which offsets proceed, there are branches from it directed upwards to the orbit, some downwards to the palate, others inwards to the nose, and one or two pass backwards to (or, perhaps better, received from) the sympathetic and facial nerves.

1. Ascending Branches.

The ascending branches, very small, and three or more in number, enter the orbit by the spheno-maxillary fissure, and supply the periosteum.*

2. Descending Branches.

The descending branches, continued chiefly from the spheno-palatine

* Bock describes a branch ascending from the ganglion to the sixth nerve; Tiedemann one to the lower angle of the ophthalmic ganglion. The filaments described by Hirzel as ascending to the optic nerve, most probably join the ciliary nerves which surround that (the optic) nerve.

branches of the upper maxillary nerve (*ante*, p. 269), are the palatine nerves (large, small, and external). They are distributed to the tonsil; to the soft palate—its glandular and muscular substance, and mucous membrane; to the gums and glands of the hard palate; and to the mucous membrane of the nose.

a. The *larger* or *anterior palatine* nerve, fig. 355,[5], descends in the largest palatine canal, and divides in the roof of the mouth into branches, which are received into grooves in the hard palate, and extend forward nearly to the incisor teeth. In the mouth it supplies the gums, glandular structure, and mucous membrane of the hard palate, and joins in front with the naso-palatine nerve. When entering its canal, this palatine nerve gives a nasal branch which ramifies on the middle and lower spongy bones; and a little before leaving the canal, another branch is supplied to the membrane covering the lower spongy bone: these are *inferior nasal branches*. Opposite the lower spongy bone springs a small branch, which is continued to the soft palate in a separate canal behind the trunk of the nerve.

b. The *smaller* or *posterior palatine* branch, fig. 355,[8], arising near the preceding nerve, enters, together with a small artery, the smaller palatine canal, and by this it is conducted to the soft palate, the tonsil, and the uvula. According to Meckel, it supplies the levator palati muscle.

c. The *external palatine* nerve, fig. 355,[7], the smallest of the series, courses between the upper maxilla and the external pterygoid muscle, and enters the external palatine canal between the maxillary bone and pterygoid process of the palate bone. At its exit from the canal it gives inwards a branch to the uvula, and outwards another to the tonsil and palate. Occasionally, this nerve is altogether wanting.

3. Internal Branches.

The internal branches furnished from the ganglion consist of the naso-palatine, and the upper and anterior nasal, which ramify in the lining membrane of the nose.

a. The *upper anterior nasal*, fig. 355, are very small branches, and enter the back part of the nasal fossa by the spheno-palatine foramen. Some few are prolonged to the posterior and upper part of the septum, and the remainder ramify in the membrane covering the upper two spongy bones, and in that lining the posterior ethmoid cells.

b. The *naso-palatine nerve* (nervus naso-palatinus,* nerve of Cotunnius), (see wood-cut in the description of the nose,) long and slender, leaves the inner side of the ganglion with the preceding branches, and after crossing the roof of the nasal fossa is directed forwards on the lower part of the septum nasi, between the periosteum and the pituitary membrane, towards the anterior palatine foramen. It descends to the roof of the mouth by a separate canal † which opens below in the centre of the anterior palatine foramen, the nerve of the right side being behind its fellow, and in a distinct canal (Scarpa). In the mouth the two naso-palatine nerves are connected one with the other, and they end in several filaments; these are distributed to the papilla behind the incisor teeth, and communicate with the great palatine nerve. In its course along the septum, small filaments are furnished from the naso-palatine nerve to the pituitary membrane.‡

* This nerve was so named by Scarpa, in an Essay (with engravings) on the nerves of the nose, published in 1785. (*Annotationes Anatomicæ*, lib. ii.) Scarpa mentions, that when his essay was prepared for the press, an engraving, containing a representation of this nerve, which Cotunnius had caused to be made twenty-three years before, was shown him by Girardi. The engraving had not, and has never been published. It is stated by John Hunter, that he dissected the nerve as early as 1754, and repeatedly used the preparation of it in his anatomical lectures. Hunter adds that, in 1782, he showed his drawings and engravings of the nerves of the nose to Scarpa, who was then in London.—See "*Observations on certain parts of the Animal Economy*," London, 1786.

† See Osteology, p. 63.

‡ Scarpa denies the existence of branches on the septum. Consult also Wrisberg, "De nervis arterias venasque comitantibus." (*Comment.*, t. i., p. 374.)

4. Posterior Branches.

The offsets directed backwards from the spheno-palatine ganglion are the vidian and pharyngeal nerves.

a. The *vidian nerve* (nerv. vidianus v. pterygoideus), fig. 355, [6], is so named from the canal of the sphenoid bone in which it is contained. Supposing this nerve to proceed backwards, as is customary in anatomical works, it arises from the back of the ganglion, which seems to be prolonged into it, courses backwards through the vidian canal, and after emerging from this divides into two branches; one of these, the superficial petrosal, joins the facial nerve, while the other, the carotid branch, communicates with the sympathetic.* Whilst the vidian nerve is in its canal, it gives inwards to the nose some small branches, the *upper posterior nasal*, which supply the membrane of the back part of the roof of the nose and septum, as well as the membrane covering the end of the Eustachian tube.

The separate course of the branches resulting from the division of the vidian nerve will now be described,

The *superficial petrosal branch*, fig. 357,[2] enters the cranium through the cartilaginous substance filling the foramen lacerum anterius at the base of the skull. Lying then on the outer side of the carotid artery and beneath the Gasserian ganglion, the nerve is directed backwards in a groove on the petrous portion of the temporal bone to the hiatus Fallopii; and it is finally continued through the hiatus Fallopii to the aqueduct of the same name, where it joins the gangliform enlargement of the facial nerve.

The *carotid* or *sympathetic portion* of the vidian nerve, shorter than the other, is of a reddish colour and softer texture. Like the preceding branch, it is surrounded by the cartilaginous substance filling the aperture (foramen lacerum anterius) at the point of the petrous portion of the temporal bone; and it is inclined backwards, also on the outer side of the carotid artery, to end in the filaments of the sympathetic surrounding that vessel.

In accordance with the view taken of the ganglia connected with the fifth nerve (p. 267), the parts of the vidian nerve, above described as directed backwards from the spheno-palatine ganglion, should be considered as beginning from the facial nerve and the carotid plexus, and coursing forwards (either separately or after being united) to join the ganglion and constitute two of its roots, the third being derived from the spheno-palatine nerves.

b. The *pharyngeal nerve* is inconsiderable in size, and instead of emanating directly from the ganglion, may be derived altogether from the vidian. This branch, when a separate nerve, springs from the back of the ganglion, enters the pterygo-palatine canal with an artery, and is lost in the lining membrane of the part of the pharynx behind the Eustachian tube.

Summary.—The upper maxillary nerve, with Meckel's ganglion, supplies the integument of the side of the head, and the muscles and integument of the lower eyelid, the side of the nose, and the upper lip. The following parts likewise receive their nerves from the same source, viz., the upper teeth, the lining membrane of the nose and upper part of the pharynx, of the antrum of Highmore, and of the posterior ethmoid cells; the soft palate, tonsil, and uvula; and the glandular and mucous structures of the roof of the mouth.

But few communications take place with other nerves. In the face the upper maxillary nerve joins freely with the facial nerve; it is, moreover, through the medium of Meckel's ganglion, connected with the facial nerve by the superficial petrosal branch of the vidian, and with the sympathetic by the carotid branch of the same nerve.

* The vidian nerve is here described, as it was by Meckel, as a single cord, dividing into parts. Some anatomists consider the petrosal and carotid branches as quite distinct one from the other in their whole length, and connected only by being contained in the same fibrous tube.

C. LOWER MAXILLARY NERVE.

The lower maxillary nerve, fig. 353,[5], is the third and largest branch of the fifth nerve. It furnishes branches to the tongue (the gustatory nerve), to the external ear, to the lower teeth, and to the muscles, the mucous membrane, and integuments about the lower maxillary bone.

This nerve is made up of two portions, which are unequal in size, the larger being derived from the Gasserian ganglion, and the smaller being the slender motor root of the fifth nerve. These two parts leave the skull by the oval foramen in the sphenoid bone, and unite immediately after their exit. A few lines beneath the base of the skull, and under the external pterygoid muscle, the lower maxillary nerve separates into two primary divisions, one of which is higher and smaller than the other. From these divisions the branches to various parts emanate as follows :—

The *small*, or *upper division*, receives nearly all the fibrils of the smaller (motor) root of the fifth nerve, and terminates in offsets to the temporal, masseter, buccinator, and pterygoid muscles. A few of the filaments of the motor root are applied to the larger division of the nerve, and are conveyed to other muscles, viz., the mylo-hyoid, the tensor of the membrane of the tympanum, and the circumflexus palati. The branches will now be considered individually.

1. Deep Temporal Branches.

The deep temporal branches are two in number, one being placed near the back part, the other near the front of the temporal fossa, and beneath the temporal muscle, to which both are distributed.

a. The *posterior branch* (r. temporalis profundus posterior) is of small size, and is sometimes conjoined with the masseteric branch. It courses upwards in a groove in the bone above the external pterygoid muscle.

b. The *anterior branch* (r. temporalis profundus anterior) is placed like the preceding between the bone and the pterygoid muscle, and is then reflected over the crest of the sphenoid bone to the fore part of the temporal fossa. It is frequently joined with the buccal nerve, and sometimes with the other deep temporal branch.

2. Masseteric Branch.

This branch is directed outwards also above the external pterygoid muscle, and has an almost horizontal course in front of the articulation of the lower maxillary bone, and through the sigmoid notch of the maxilla, to the inner surface of the masseter muscle. It ramifies in the muscle nearly to its lower end. When the nerve passes by the articulation of the lower jaw, it gives one or more filaments to that joint, and occasionally it furnishes a branch to the temporal muscle.

3. Buccal Branch.

The buccal branch (r. buccinatorius, v. buccinatorio-labialis) pierces the substance of the external pterygoid muscle, and courses forwards to the face under cover of the ramus of the lower maxillary bone, or through the fibres of the temporal muscle. On the buccinator muscle, its fibres separate into *two branches*, which will be presently noticed.

From the buccal nerve, while passing through the pterygoid muscle, is given a branch (pterygoid) to that muscle; and when it has passed beyond the same muscle, two or three ascending offsets are furnished to the temporal muscle. Under the ramus of the maxilla it gives filaments to the upper part of the buccinator; these perforate the fibres of the muscle, and end in the buccal glands and the mucous membrane lining the inner surface of the muscle.

a. The *upper branch* of the two into which the buccal nerve divides communicates with the facial nerve in a plexus around the facial vein, and supplies the integument and the upper part of the buccinator muscle.

b. The *lower branch,* directed to the angle of the mouth, forms, like the upper one, a plexus around the facial vein, and is distributed to the integument, to the buccinator muscle and the mucous membrane lining it, as well as (according to Meckel) to the muscles of the angle of the mouth.*

4. Pterygoid Branches.

The pterygoid branches are two in number: one for each of the pterygoid muscles.

a. The *external pterygoid branch* is most frequently derived from the buccal nerve. It may be a separate offset from the smaller portion of the lower maxillary nerve.

The *nerve* of the *internal pterygoid* muscle, fig. 356, at its origin is closely connected with the otic ganglion, and enters the inner or deep surface of the muscle.

The *lower* and *larger division* of the lower maxillary nerve divides into three parts, viz., the auriculo-temporal, gustatory, and lower dental. The auriculo-temporal soon leaves the short common trunk, and the other two nerves separate one from the other afterwards, at a variable distance below the base of the skull.

1. AURICULO-TEMPORAL NERVE.

The auriculo-temporal nerve (nerv. temporalis superficialis), fig. 353, as the name implies, is distributed to the ear and the temple.

The nerve often commences by two roots, between which may be placed the middle meningeal artery. It is directed at first backwards, beneath the external pterygoid muscle, to the inner side of the articulation of the jaw; and then changing its course, turns upwards between the ear and the joint, where it is covered by the parotid gland. Lastly, emerging from beneath the parotid, it divides into two temporal branches.

Branches.—Besides the terminal branches just referred to, the auriculo-temporal nerve furnishes branches to the ear, the temporo-maxillary joint, and the parotid gland, as well as communicating filaments to other nerves. These will now be severally noticed.

a. The *auricular branches* are two in number. One of these, the *lower* of the two, arising behind the articulation of the jaw, distributes branches to the ear below the external meatus; and other filaments, turning round the internal maxillary artery, join the sympathetic nerve.

The *upper auricular branch,* leaving the nerve in front of the ear, enters the integument covering the tragus and the pinna above the external auditory meatus. Both auricular nerves are confined to the outer surface of the ear.—See *Nerves of the External Ear.*

b. Branches communicating with the facial nerve, and the otic ganglion.—The

* "De quinto pare nervorum cerebri," in Ludwig.—"*Scriptores Neurologici,*" t. i.

branches which join the facial nerve, commonly two in number, pass forward around the carotid artery. The filaments to the otic ganglion arise near the beginning of the auriculo-temporal nerve.

c. Branches to the meatus auditorius and temporo-maxillary articulation.—The nerves to the meatus, two in number, spring from the point of connexion of the facial and auriculo-temporal nerves, and enter the interior of the auditory meatus between its osseous and cartilaginous parts. One or two filaments sometimes perforate the cartilage and are lost on the convex surface of the meatus. The nerve to the articulation comes from the preceding branches, or directly from the auriculo-temporal nerve.

d. The *parotid branches* are given from the nerve while it is covered by the gland.

e. Temporal Branches.—One of these, the smaller and *posterior* of the two, supplies the anterior muscle of the auricle, and distributes filaments to the upper part of the pinna and the integument above it. The *anterior* temporal branch extends with the superficial temporal artery to the top of the head, and ends in the integument.* It is often united with the temporal branch of the upper maxillary nerve.

2. GUSTATORY NERVE.

The gustatory nerve, or lingual branch of the fifth, fig. 353, has an oblique direction inwards, under cover of the lower maxillary bone, to the tongue.

This nerve is deeply placed in the whole of its course, and has the following connexions with surrounding parts. At first it is beneath the external pterygoid muscle with the dental nerve, lying to the inner side of that nerve, and is sometimes united to it by a cord which crosses over the internal maxillary artery. In the same place the gustatory nerve is joined at a small angle by the chorda tympani. Next, it is placed between the internal pterygoid muscle† and the lower maxilla; and it is then inclined obliquely inwards to the side of the tongue, over the upper constrictor of the pharynx, (where this muscle is attached to the maxillary bone,) and above the deep portion of the submaxillary gland. Lastly, the nerve is continued along the side of the tongue to its apex, lying below the sublingual gland and in contact with the mucous membrane of the mouth.

The *branches*, which are few, leave the nerve by the side of the tongue. Some supply the mucous membrane of the mouth and the contiguous salivary glands; some enter the tongue and its papillæ; and others connect the gustatory nerve with the hypoglossal nerve and the submaxillary ganglion.

a. The branches to the submaxillary ganglion are two or three in number. (See *Submaxillary Ganglion.*)

b. Those which are connected with offsets from the hypoglossal nerve form a plexus at the inner border of the hyoglossus muscle.

c. The branches distributed to the mucous membrane of the mouth are given from the nerve by the side of the tongue, and supply the gums also.

d. Some delicate filaments are likewise distributed to the substance of the sublingual gland.

The lingual or terminal branches perforate the muscular structure of the tongue, and divide into filaments, which are continued almost vertically upwards to the conical and fungiform papillæ. Near the tip of the tongue the branches of the gustatory and hypoglossal nerves are united.

* Meckel mentions a communication between this branch and the occipital nerve.
† It has been observed by Meckel to give filaments to this muscle (op. cit.)

3. INFERIOR DENTAL NERVE.

The inferior dental nerve (maxillaris inferior, Meckel), fig. 353, is the largest of the three branches of the lower maxillary nerve. It courses forwards through the lower maxillary bone, and terminates on the face.

Before the nerve enters the canal in the lower maxilla, it has the same relative position as the gustatory nerve, near which it lies,—that is to say, it is first beneath the external pterygoid muscle, and then between the internal pterygoid and the ramus of the lower maxilla, but separated from the muscle by the internal lateral ligament of the articulation. Being then received into the canal appropriated to it and the dental artery in the bone just named, the nerve is conducted forwards beneath the teeth, to which it gives filaments, as far as the foramen (mental) in the side of the bone. Here it bifurcates: one part, the incisor branch, is continued onwards within the bone to the middle line; the other (labial branch) escapes by the foramen to the face.

In addition to the branches already indicated, the dental nerve, when about to enter the foramen on the inner surface of the ramus of the jaw, gives off a slender offset, the mylo-hyoid branch.

a. The *mylo-hyoid branch* is lodged in a groove on the inner surface of the ramus of the maxillary bone, in which it is confined by fibrous membrane, and is distributed to the lower or cutaneous surface of the mylo-hyoid muscle and to the anterior belly of the digastric muscle. Occasionally one or two filaments of this nerve enter the submaxillary gland.

b. The *dental branches* supplied to the molar and bicuspid teeth correspond to the number of the fangs of those teeth. Each branch enters the hole in a fang, and terminates in the pulp of the tooth.

c. The *incisor branch* has the same direction as the trunk of the nerve; it extends to the middle line from the point of origin of the labial branch, and supplies nerves to the canine and incisor teeth.

d. The *labial* (mental?) *branch*, emerging from the bone by the foramen on its outer surface, divides beneath the depressor of the angle of the mouth into two parts.

One of these, the outer division, supplies the depressor anguli oris and orbicularis oris muscles, and the integument. It communicates with the facial nerve.

The inner division, the larger of the two, ascends to the lower lip beneath the quadratus menti muscle, to which it gives filaments: the greater number of the branches end on the inner and outer surfaces of the lip. These (inner) branches assist but slightly in forming the plexus of union with the facial nerve.

Summary.—The lower maxillary, or third division of the fifth, is partly a compound nerve. It furnishes a nerve of special sense to the tongue (the gustatory nerve). Cutaneous filaments ramify on the side of the head, and the external ear, in the auditory passage, the lower lip, and the lower part of the face. Branches are furnished to the mucous membrane of the mouth, the lower teeth and gums, the salivary glands, and the articulation of the lower jaw.

This nerve supplies the muscles of mastication (viz., the masseter, temporal, and two pterygoid), also the buccinator, the mylo-hyoid, the circumflexus palati, and the tensor of the tympanum; and the smaller or motor part of the fifth nerve being distributed among the branches furnished to these muscles, each is a compound nerve. The muscles of the lower lip and angle of the mouth likewise receive offsets from

the lower maxillary nerve; but these muscles are also furnished with branches from the facial nerve.

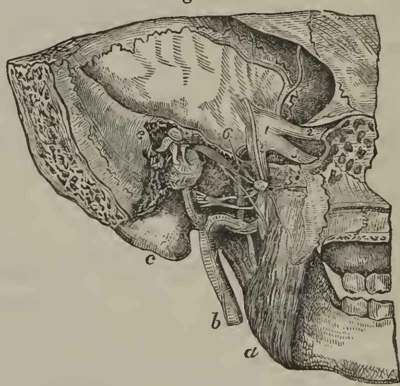
The gustatory nerve communicates with the facial nerve through the chorda tympani, and with the hypoglossal nerve both on the hyoglossus muscle and in the substance of the tongue. The auriculo-temporal nerve is connected with the same nerve in the substance of the parotid gland. Lastly, the inferior dental joins the facial nerve, forming a large plexus in which the nerves are freely united one with the other.

Ganglia connected with the inferior maxillary nerve.—Two small ganglia (otic and submaxillary), having the general characters and arrangement ascribed to these bodies (*ante*, page 267), are connected with the lower maxillary nerve: one with the trunk of the nerve, the other with its lingual branch (the gustatory nerve).

Otic Ganglion.

The otic ganglion (gang. oticum v. auriculare,—Arnold), fig. 356, of a reddish gray colour, is situate on the deep surface of the lower maxillary nerve, nearly at the point of junction of the motor fasciculus with that nerve, and around the origin of the internal pterygoid branch. Its outer side is thus in contact with the lower maxillary nerve; its inner surface is close to the cartilaginous part of the Eustachian tube and the circumflexus palati muscle; and behind it is the middle meningeal artery.

Fig. 356.



The otic ganglion seen from the inner side. (From Arnold.) *a.* Internal pterygoid muscle. *b.* Carotid artery with the sympathetic. *c.* Mastoid process. *d.* Membrane of tympanum. *e.* Bones of tympanum. 1. Gasserian ganglion. 2. First division of fifth. 3. Second division. 4. Third division. 5. Branch to tensor palati. 6. Small superficial petrosal nerve. 7. Chorda tympani. The nerve of the internal pterygoid muscle is seen on the muscle.

The nervous filaments attached to this ganglion are divisible into those by which it is connected with nerves, and those given to it from certain muscles.

Connexion with nerves—roots.—The ganglion is connected with the lower maxillary nerve, especially with the branch furnished to the internal pterygoid muscle and with the auriculo-temporal nerve, and is believed thus to obtain motor and sensory fibrils or roots; it is brought into connexion with the sympathetic by a filament from the plexus on the middle meningeal artery. This ganglion has likewise communication with the glosso-pharyngeal and facial nerves by means of the small petrosal nerve prolonged to it from the tympanic plexus.

Branches.—Two small nerves are distributed to muscles—one to the tensor of the membrane of the tympanum, the other to the circumflexus palati. The latter leaves the fore part of the ganglion; the former is directed backwards outside the Eustachian tube to the osseous canal containing the muscle for which it is destined. (See the figure.)

Submaxillary Ganglion.

The submaxillary ganglion (ganglion maxillare,—Meckel), fig. 353, is placed above the deep portion of the submaxillary gland, and is connected by filaments with the gustatory nerve. It is about the size of the ophthalmic ganglion. By the upper part or base it receives branches from nerves (roots), whilst from the lower part proceed the offsets which are distributed from the ganglion.

Connexion with nerves—roots.—A few filaments are derived from the gustatory nerve, and of these one or two are connected with both the fore and back part of the ganglion. The ganglion, it is believed, also receives, at its back part, a branch from the facial nerve; this is the chorda tympani, prolonged to the ganglion by the side of the gustatory nerve. The connexion with the sympathetic takes place by means of an offset from the filaments on the facial artery.

Branches.—Some nerves, five or six in number, radiate to the substance of the submaxillary gland. Others from the fore part of the ganglion, longer and larger than the preceding, end in the mucous membrane of the mouth, and in Wharton's duct.*

A difference may be noticed between the structures to which the ganglia above described furnish offsets. The otic ganglion supplies muscles exclusively, while the submaxillary ganglion gives no muscular offsets.

SIXTH PAIR OF NERVES.

The sixth cranial nerve (nerv. abducens, par sextum), fig. 351, [5], is distributed exclusively to the outer rectus muscle in the orbit, and from the action assigned to that muscle, it is sometimes named the "abducent nerve" of the eyeball.

From the point of origin, the nerve courses forwards at the base of the skull, through the cavernous sinus and the sphenoidal fissure to the orbit. It enters the sinus by an opening in the dura mater behind the body of the sphenoid bone, but is separated from the blood by the thin lining membrane. In the sinus this nerve lies on the outer side of the carotid artery, and here receives one or two filaments of communication from the sympathetic. In entering the orbit (between the heads of the external rectus muscle) it is above the ophthalmic vein. The nerve is distributed to the outer rectus by two or three filaments, which pierce the ocular surface of the muscle.†

SEVENTH PAIR OF NERVES.

In the seventh cranial nerve of Willis are combined two nerves having a distinct origin, distribution, and function. One of these (facial) is the motor nerve of the face; the other (auditory) is the special nerve of the sense of hearing. Both enter the internal auditory meatus in the temporal bone, but they are soon separated one from the other.

* According to Meckel ("De quinto pare," &c.), a branch occasionally descends in front of the hyo-glossus muscle, and after joining with one from the hypoglossal nerve, ends in the genio-hyo-glossus muscle.

† The sixth nerve, according to Bock ("*Beschreibung des Fuenften Nervenpaares*"—1817), is joined in the orbit by a filament from Meckel's ganglion.

A. FACIAL NERVE.

The place of origin of the facial nerve (nerv. durus paris septimi,—Willis; seventh cranial nerve,—Sœmmerring) has been mentioned in connexion with the account given of the nervous centre. Its course being tortuous and its branches numerous, it will be convenient to divide the description of this nerve into two parts: the first part comprising the portion which intervenes between the origin of the nerve and its entrance into the parotid gland; the second, extending to the termination of the nerve.

THE NERVE FROM ITS ORIGIN TO THE PAROTID GLAND.

From its place of origin, the facial nerve is inclined outwards with the auditory nerve to the internal auditory meatus. The facial lies in a groove on the auditory nerve, and the two are united in the auditory meatus by one or two nervous filaments. At the bottom of the meatus the facial nerve enters the aqueduct of Fallopius, and follows the windings of that canal to the surface of the skull. The course through the temporal bone is first almost horizontal outwards, between the cochlea and vestibule, to the inner wall of the tympanum, and it is then turned suddenly backwards above the fenestra ovalis towards the pyramid. Where it bends, the nerve presents a reddish gangliform enlargement (intumescentia ganglioformis), which marks the junction of several nerves. Opposite the pyramid it is arched downwards behind the tympanum to the stylo-mastoid foramen, by which it leaves the osseous canal.

Within the temporal bone the facial is connected with several other nerves by separate branches; and immediately after issuing through the stylo-mastoid foramen, it gives off three small branches,—viz., the posterior auricular, digastric, and stylo-hyoid nerves.*

1. Connexions with other Nerves.

a. Filaments to the auditory nerve.—In the meatus auditorius one or two minute filaments pass between the facial and the trunk of the auditory nerve.

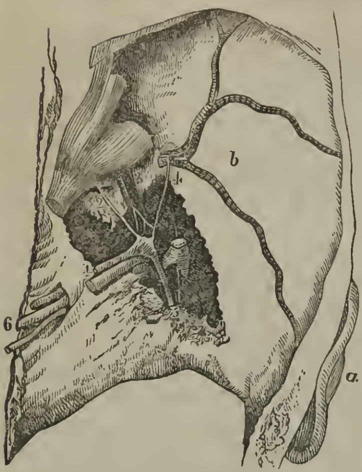
b. Nerves connected with the gangliform enlargement.—About two lines from the beginning of the aqueduct of Fallopius, where the facial nerve swells into a gangliform enlargement, it is joined by the large superficial petrosal branch, fig. 357,[2] from the vidian nerve. To the same enlargement of the facial nerve are likewise united a filament from the small superficial petrosal nerve, fig. 357[3], derived from the tympanic nerve,† and lastly, the external superficial petrosal nerve, fig. 357,[4] which is furnished by the sympathetic accompanying the middle meningeal artery.‡

* Some anatomists describe a branch to the stapedius muscle. But the existence of a muscle, and therefore of the nerve, is doubtful.

† There is a difference in opinion concerning this branch, arising from its smallness and the difficulty of determining from what nerve it is primarily derived. According to one opinion, the small superficial petrosal nerve is the continuation to the otic ganglion of the tympanic nerve (Jacobson's), and is united by a filament to the enlargement of the facial. According to another manner of viewing the nerve, it begins in the swelling on the facial, connects the facial with the otic ganglion, and receives only a filament of union from Jacobson's nerve.

‡ This nerve, named and described by Bidder, enters a canal on the upper surface of the petrous portion of the temporal bone, external to the small superficial petrosal, and commonly joins the facial beyond the swelling.

Fig. 357.



This drawing represents the middle fossa of the base of the skull with the petrous part of the temporal bone cut through so as to expose the nerves joining the facial; (from Bidder)—*a.* External ear. *b.* Middle fossa of the skull with the middle meningeal artery branching on it. 1. Facial nerve by the side of the auditory. 2. Large superficial petrosal nerve. 3. Small superficial petrosal nerve lying over the tensor tympani muscle. 4. The external superficial petrosal nerve. 5. Chorda tympani. 6. Eighth nerve.

c. Filaments from the auricular branch of the pneumogastric.—Near the exit of the facial nerve from the aqueduct of Fallopius it is joined by one or more of these filaments.

2. Chorda Tympani.

The nerve thus named leaves the trunk of the facial nerve below the level of the pyramid,* and crosses the tympanum to join the gustatory nerve, along which it is believed to be conducted to the submaxillary ganglion. After passing through a short canal behind the tympanum, it enters that cavity by an aperture below the level of the pyramid, and close to the ring of bone containing the membrane of the tympanum; and being invested by the mucous lining of the cavity, it is directed forwards across the membrana tympani and the handle of the malleus to a foramen at the inner side of the Glasserian fissure. After emerging from the tympanum through the opening referred to, the nerve lies beneath the external pterygoid muscle, and is inclined obliquely forwards to the gustatory nerve, which it meets at an acute angle. Lastly, coursing along the gustatory nerve, with which it is connected by one or more filaments, the chorda tympani ends in the submaxillary ganglion,—or, according to some anatomists, joins inseparably with that nerve.

3. Posterior Auricular Branch.

This branch, fig. 358,[2] arises close to the stylo-mastoid foramen: it turns backwards below the external auditory meatus, and is joined by the auricular branch of the pneumogastric. Arrived in front of the mastoid process, it divides into an auricular and an occipital portion; in this situation, either the nerve or one of its branches is further connected with the great auricular nerve of the cervical plexus.

The *auricular division* supplies fasciculi to the retrahent muscle of the ear, and ends in the integument on the posterior aspect of the auricle.

The *occipital branch* is directed backwards beneath the small occipital nerve (from the cervical plexus) to the posterior part of the occipito-frontalis muscle; it lies close to the bone, and, besides supplying the muscle, gives upwards filaments to the integument.

4. Digastric and Stylo-hyoid Branches.

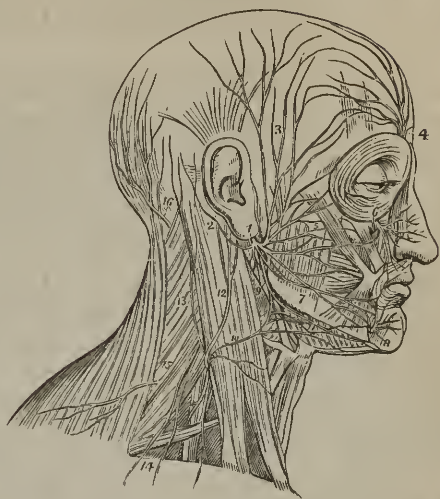
The *digastric branch* arises in common with that for the stylo-hyoid muscle, and is split into many filaments, which enter the digastric muscle: one of these, after perforating the digastric, joins the glosso-pharyngeal nerve near the base of the skull.

The *stylo-hyoid branch*, long and slender, is directed inwards from the digastric branch to the muscle from which it is named. This nerve is connected with the carotid plexus of the sympathetic nerve.

* Other views are taken of the origin of this nerve. Thus it is said to arise from the gangliform enlargement of the facial, and to accompany this nerve to the foramen by which it enters the tympanum; or, that it is only a prolongation from the large superficial petrosal (Vidian), which courses along the facial nerve without joining it, and becomes the chorda tympani.

THE FACIAL NERVE FROM THE STYLO-MASTOID FORAMEN TO ITS END.

[Fig. 358.



The distribution of the facial nerve and the branches of the cervical plexus. 1. The facial nerve, escaping from the stylo-mastoid foramen, and crossing the ramus of the lower jaw; the parotid gland has b en removed in order to see the nerve more distinctly. 2. The posterior auricular branch; the digastric and stylo-mastoid filaments are seen near the origin of this branch. 3. Temporal branches, communicating with (4) the branches of the frontal nerve. 5. Facial branches, communicating with (6) the infra-orbital nerve. 7. Facial branches, communicating with (8) the mental nerve. 9. Cervico-facial branches, communicating with (10) the superficialis colli nerve, and forming a plexus (11) over the submaxillary gland. The distribution of the branches of the facial in a radiated direction over the side of the face and their looped communications constitute the pes anserinus. 12. The auricularis magnus nerve, one of the ascending branches of the cervical plexus. 13. The occipitalis minor, ascending along the posterior border of the sterno-mastoid muscle. 14. The superficial and deep descending branches of the cervical plexus. 15. The spinal accessory nerve, giving off a branch to the external surface of the trapezius muscle. 16. The occipitalis major nerve, the posterior branch of the second cervical nerve.—W.]

In this part of its course the facial nerve is continued forwards through the substance of the parotid gland, and divides in the gland, behind the ramus of the lower maxilla, into two primary branches, from which numerous offsets spread out over the side of the head, the face, and the upper part of the neck. The two primary divisions of the nerve are named temporo-facial and cervico-facial: they are at first flattened and subdivided. This part of the nerve, with its divisions, is known as the "pes anserinus."*

The TEMPORO-FACIAL DIVISION, the larger of the two, takes the direction of the trunk of the facial nerve through the parotid gland. Its ramifications and connexions with other nerves form a network over the side of the face, extending as high as the temple, and as low as the mouth. These branches are arranged into temporal, malar, and infra-orbital sets.

Near its commencement this division of the facial is connected with the auriculo-temporal nerve (of the fifth) by one or two filaments which turn round the external carotid artery; and it gives some filaments to the tragus of the outer ear.

a. The *temporal branches* ascend over the zygoma to the side of the head. Some end in the anterior muscle of the auricle, and the integument of the temple, and communicate with the temporal branch of the upper maxillary nerve near the ear, as well as with (according to Meckel) the auriculo-temporal branch of the lower maxillary nerve. Other branches enter the occipito-frontalis, and the orbicular muscle of the eyelids, and join offsets from the supraorbital branch of the ophthalmic nerve.

b. The *malar branches* cross the malar bone to the outer angle of the orbit, and

* The designation appears to have originated in a comparison made by Winslow.

supply the orbicular muscle and the corrugator of the eyebrow. Some filaments are distributed to both the upper and the lower eyelid: those in the upper eyelid join filaments from the lachrymal and supraorbital nerves; those in the lower lid are connected with filaments from the upper maxillary nerve. Filaments from this series communicate with the malar branch (r. subcutaneus malæ) of the upper maxillary nerve.

c. The *infraorbital branches*, of larger size than the other branches, are almost horizontal in direction, and are distributed between the orbit and mouth. They supply the buccinator and orbicularis oris muscles, the elevators of the upper lip and angle of the mouth, and likewise the integument. Numerous communications take place with the fifth nerve. Beneath the elevator of the upper lip these nerves are united in a plexus with the branches of the upper maxillary nerve; on the side of the nose they communicate with the nasal, and at the inner angle of the orbit with the infratrochlear nerve. The lower branches of this set are connected with the cervico-facial division.

The CERVICO-FACIAL DIVISION of the facial nerve is directed obliquely through the parotid towards the angle of the lower jaw, and gives branches to the face, below those of the preceding division, and to the upper part of the neck. The branches are named buccal, supramaxillary, and inframaxillary. In the gland this division of the facial nerve is joined by filaments of the great auricular nerve of the cervical plexus, and offsets from it enter the substance of the gland.

a. The *buccal branches* communicate with the temporo-facial division, cross the masseter muscle, and join on the buccinator muscle with filaments of the buccal branch of the lower maxillary nerve.

b. The *supramaxillary branch*, fig. 358, sometimes double, gives an offset over the side of the maxilla to the angle of the mouth, and is then directed inwards, beneath the depressor of the angle of the mouth, to the muscles and integument between the lip and chin: it joins with the labial branch of the lower dental nerve.

c. The *inframaxillary branches* (r. subcutanei colli), fig. 358, perforate the deep cervical fascia, and, placed beneath the platysma muscle, form arches across the side of the neck as low as the hyoid bone. Some branches join the superficial cervical nerve beneath the platysma, others enter that muscle, and a few perforate it to end in the integument.

Summary.—The facial nerve is the motor nerve of the face. It is distributed to the muscles of the ear and of the scalp; to those of the mouth, nose, and eyelids; and to the cutaneous muscle of the neck (platysma). It likewise supplies branches to the integument of the ear, of the side and back of the head, as well as to that of the face, and the upper part of the neck.

This nerve is connected freely with the three divisions of the fifth nerve, and with the submaxillary and spheno-palatine ganglia; with the glosso-pharyngeal and pneumogastric nerves; with the auditory, the sympathetic, and the spinal nerves.

B. AUDITORY NERVE.

The auditory nerve (nervus mollis paris septimi,—Willis, eighth cranial nerve of Sœmmerring) is the special nerve of the sense of hearing, and is distributed exclusively to the internal ear.

As the auditory nerve is inclined outwards from its connexion with the medulla oblongata to gain the internal auditory meatus, it is in contact with the facial nerve, but a small arterial branch destined for the internal ear partially separates them. Within the meatus the two

nerves are connected one to the other by one or two small filaments. Finally the auditory nerve bifurcates in the meatus: one of the parts is the nerve of the cochlea; the other enters the vestibule of the internal ear. The distribution of these branches will be described with the ear.

EIGHTH PAIR OF NERVES.

The eighth cranial nerve is composed of three distinct nerves—the glosso-pharyngeal, pneumogastric, and spinal accessory. Besides issuing from the skull by the same foramen, these nerves have but little in common. Two of them, the glosso-pharyngeal and pneumogastric, are attached to the medulla oblongata in the same line, and resemble one another somewhat in their distribution, for both are distributed to the beginning of the alimentary canal. But the other, the spinal accessory, takes its origin from the spinal cord, and is distributed exclusively to muscles.

A. GLOSSO-PHARYNGEAL NERVE.

The glosso-pharyngeal nerve (one division of the eighth pair, ninth cranial nerve of Sœmmerring), fig. 361,[1], is destined, as the name implies, for the tongue and pharynx.

This small nerve is directed outwards from its place of origin over the flocculus to the foramen lacerum jugulare, through which it leaves the skull with the pneumogastric and spinal accessory nerves, but in a separate tube of dura mater.* In passing through the foramen, where it is placed somewhat in front of the other nerves, this nerve is contained in a groove, or in a canal in the lower border of the petrous portion of the temporal bone, and presents, successively, two ganglionic enlargements,—the jugular ganglion, and the petrous ganglion.

In the neck the glosso-pharyngeal nerve is very deeply placed at its commencement, but less so towards its termination. After leaving the skull, it soon appears between the internal carotid artery and the jugular vein; and in its course to the tongue and pharynx is at first directed downwards over the carotid artery and beneath the styloid process and the muscles connected with the process, to the lower border of the stylo-pharyngeus muscle. Here, changing its direction, the nerve curves inwards to the tongue, forming an arch on the side of the neck. In this last part of its course, it is placed on the stylo-pharyngeus and the middle constrictor muscle of the pharynx, above the upper laryngeal nerve; and near the tongue it is beneath the hyo-glossus muscle, where it ends in offsets distributed to the pharynx, the tonsil, and the tongue.

The *jugular ganglion*† (gang. superius vel jugulare), fig. 361,[4] the smaller of the two ganglia of the glosso-pharyngeal nerve, is situate

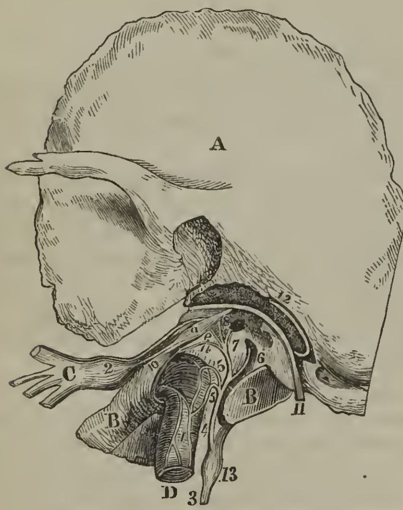
* The jugular foramen has two projecting points of bone for the attachment of separate portions of the dura mater. Thus the foramen is divided into three parts: one in front for the lower petrosal sinus, one behind for the lateral sinus, and a central one for the three nerves.

† This ganglion was known to Ehrenritter, but it has been particularly described by Müller.—See "*Medicinische Zeitung herausgegeben von dem Verein fur Heilkunde in Preussen.*" Berlin, 1833; and Müller's "Archiv f. Anat. u. Physiol.," 1834 and 1837.

at the upper part of the osseous groove in which the nerve is laid during its passage through the jugular foramen. Its length is from half a line to a line, and the breadth from half to three-fourths of a line. It is placed on the outer side of the trunk of the nerve, and involves only some of the fibres,—a small fasciculus passing by the ganglion, and joining the nerve below it.

The *petrous ganglion* (ganglion inferius vel petrosum,—Andersch), fig. 361,[6] is contained in a hollow in the lower border of the petrous part of the temporal bone, (receptaculum ganglioli petrosi), and measures about three lines in length. This ganglion includes all the filaments of the nerve, and resembles the gangliform enlargement of the facial nerve. From it arise the small branches by which the glosso-pharyngeal is connected with other nerves at the base of the skull: these are the tympanic nerve, and branches to join the pneumogastric and sympathetic.

Fig. 359.



A drawing of the tympanic nerve from Breschet's work on the ear. A Squamous part of temporal bone. B. Petrous portion of same. C. Lower maxillary nerve. D. Internal carotid artery. *a*. Tensor tympani muscle. 1. Carotid plexus. 2. Otic ganglion. 3. Glosso-pharyngeal nerve. 4. Tympanic nerve. 5. Branches to carotid plexus. 6. Branch to fenestra rotunda. 7. Branch to fenestra ovalis. 8. Branch to join the large superficial petrosal nerve. 9. Small superficial petrosal nerve. 10. Nerve to tensor tympani muscle. 11. Facial nerve. 12. Chorda tympani. 13. Petrous ganglion of the glosso-pharyngeal. 14. Branch to the membrane lining the Eustachian tube.

The *branches* of the glosso-pharyngeal nerve are divisible into two series: in the first will be ranged those derived from the petrous ganglion, and serving chiefly to connect this nerve with others; and the second will comprise the nerves distributed from it in the neck.

CONNECTING BRANCHES, AND TYMPANIC BRANCH.

1. From the petrous ganglion spring three small filaments:—One passes to the auricular branch of the pneumogastric, one to the upper ganglion of the sympathetic, or *vice versâ*, and a third to the ganglion of the root of the pneumogastric. The last is not very constant.

2. The *branch* to or from the *facial nerve* perforates the digastric muscle; it is connected with the trunk of the glosso-pharyngeal below the petrous ganglion.*

3. The *tympanic branch* (nerve of Jacobson; r. tympanicus), fig. 359,[4] arises from the petrous ganglion, and is conducted to the tympanum by a special canal† in the petrous part of the temporal bone. On the inner wall of the tympanum, fig. 359, the nerve

* There is sometimes another branch to the trunk of the pneumogastric.

† The orifice of this canal is in the ridge of bone between the jugular fossa and the carotid foramen; and the canal is directed upwards to the inner wall of the tympanum. From it three channels branch off: one bends down to the carotid canal; a second ascends to the hiatus Fallopii; and the third reaches the upper part of the petrous portion of the temporal bone, external to the hiatus Fallopii.

joins with an offset,[5] from the sympathetic in a plexus (tympanic), and distributes filaments to the membrane lining the tympanum and the Eustachian tube, as well as one,[6] to the fenestra rotunda, and another,[7] to the fenestra ovalis.

From the tympanic nerve are given three *connecting branches*, by which it communicates with other nerves; these occupy the channels continued from the osseous canal, through which the nerve enters the tympanum. One branch enters the carotid canal and joins with the sympathetic on the carotid artery.* A second, fig. 359,[8], is united to the large superficial petrosal nerve, as this lies in the hiatus Fallopii. And the third, fig. 359,[9], is directed upwards, beneath the canal for the tensor tympani muscle, towards the surface of the petrous portion of the temporal bone, where it becomes the *small superficial petrosal nerve*,† and under this name is continued to the exterior of the skull through a small aperture in the sphenoid and temporal bones, to end in the otic ganglion. As this petrosal nerve passes by the gangliform enlargement of the facial, it has a connecting filament with that enlargement.‡

BRANCHES DISTRIBUTED IN THE NECK.

1. The *carotid branches* course along the internal carotid artery, and unite with the pharyngeal branch of the pneumogastric and with branches of the sympathetic.
2. The *pharyngeal branches*, three or four in number, unite opposite the middle constrictor of the pharynx with branches of the pneumogastric and sympathetic to form the *pharyngeal plexus*. Nerves to the mucous membrane of the pharynx perforate the muscles, and extend upwards to the base of the tongue and the epiglottis, and downwards nearly to the hyoid bone.
3. The *muscular branches* are given to the stylo-pharyngeus and constrictor muscles.§
4. *Tonsillitic branches.* When the glosso-pharyngeal nerve is near the tonsil, some branches are distributed on this body in a kind of plexus (circulus tonsillaris). From these nerves, offsets are sent to the soft palate and the isthmus of the fauces, where they join the palatine nerves.
5. *Lingual branches.* The glosso-pharyngeal nerve divides into two parts at the border of the tongue. One turns to the upper surface of the tongue, supplying the mucous membrane at its base; the other perforates the muscular structure, and ends in the mucous membrane as far forwards as the papillæ circumvallatæ, and filaments enter those papillæ.

Summary. — The glosso-pharyngeal distributes branches to the mucous membrane of the tongue and pharynx. The muscles supplied by it are some of those of the pharynx and base of the tongue. It is connected with the following nerves, viz.,—the lower maxillary division of the fifth, the facial, the pneumogastric (the trunk and branches of this nerve), and the sympathetic.

B. PNEUMOGASTRIC NERVE.

The pneumogastric nerve (nervus vagus, par vagum, sympatheticus medius, a division of the eighth pair of Willis, tenth cranial nerve,—Sœmmerring), fig. 360,[11], has the longest course of any of the cranial

* Or this filament may be said to spring from the carotid plexus, and join Jacobson's nerve in the tympanic plexus.

† Bidder always found the small superficial petrosal nerve in an osseous canal—never on the surface of the bone. This observer states, too, that the nerve passes from the skull through the sphenoid bone and the petrous portion of the temporal.—"*Neurologische Beobachtungen.*"

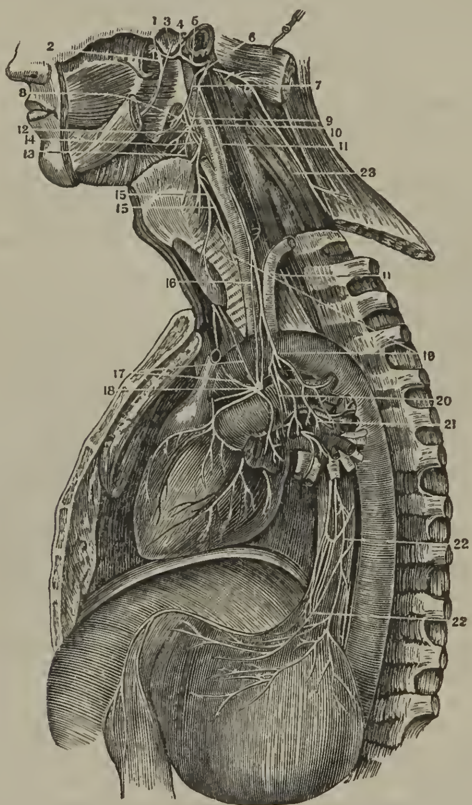
‡ Jacobson described an anterior or internal branch given from the tympanic nerve to the spheno-palatine ganglion.

§ An additional muscular nerve to the digastric and stylo-hyoid muscles is noticed by Cruveilhier.—*Anat. Descrip.* t. iv. It is probable that this nerve is but the connecting branch between the facial and glosso-pharyngeal nerves.

nerves. It extends through the neck and the cavity of the chest to the upper part of the abdomen; and it supplies nerves to the organs of voice and respiration, to the alimentary canal as far as the stomach, and to the heart.

THE NERVE FROM ITS ORIGIN TO THE THORAX.—The filaments by which this nerve arises from the medulla oblongata are collected together, so as to give rise to a flat fasciculus, which is directed over the flocculus to the foramen lacerum in the base of the skull.

[Fig. 360.



A view of the distribution of the glosso-pharyngeal, pneumogastric, and spinal accessory nerves, or the eighth pair. 1. The inferior maxillary nerve. 2. The gustatory nerve. 3. The chorda tympani. 4. The auricular nerve. 5. Its communication with the portio dura. 6. The facial nerve coming out of the stylo-mastoid foramen. 7. The glosso-pharyngeal nerve. 8. Branches to the stylo-pharyngeus muscle. 9. The pharyngeal branch of the pneumogastric nerve descending to form the pharyngeal plexus. 10. Branches of the glosso-pharyngeal to the pharyngeal plexus. 11. The pneumogastric nerve. 12. The pharyngeal plexus. 13. The superior laryngeal branch. 14. Branches to the pharyngeal plexus. 15, 15. Communication of the superior and inferior laryngeal nerves. 16. Cardiac branches. 17. Cardiac branches from the right pneumogastric nerve. 18. The left cardiac ganglion and plexus. 19. The recurrent or inferior laryngeal nerve. 20. Branches sent from the curve of the recurrent nerve to the pulmonary plexus. 21. The anterior pulmonary plexus. 22, 22. The œsophageal plexus.—Quain.]

In passing through the opening at the base of the skull the pneumogastric nerve is contained in the same sheath of dura mater, and surrounded by the same tube of arachnoid membrane as the spinal accessory nerve; but it is separated from the end of the lateral sinus by a process of fibrous membrane, or of bone, and from the glosso-pharyngeal nerve by a process of membrane. In the foramen the filaments of the nerve become aggregated together; and it here presents a ganglionic enlargement, distinguished as the ganglion of the root of the pneumogastric.

After its passage through the foramen, the vagus nerve is joined by the accessory part of the spinal accessory nerve, and a second ganglion is formed upon it (the ganglion of the trunk of the nerve). Several communications are at the same time established with the surrounding nerves. In its course along the neck the nerve has a straight direction, and a fixed position with respect to the cervical vessels; for, enclosed in the sheath of those vessels, it is between the internal carotid artery and the internal jugular vein as far as the thyroid cartilage, and afterwards between the same vein and the common carotid artery. When entering the thorax, the nerve of the right side crosses over the subclavian artery at right angles, and gives the recurrent branch to the larynx round that vessel; but on the left side it is parallel with the subclavian artery, and the recurrent laryngeal branch arises in the chest opposite the arch of the aorta.

Fig. 361.

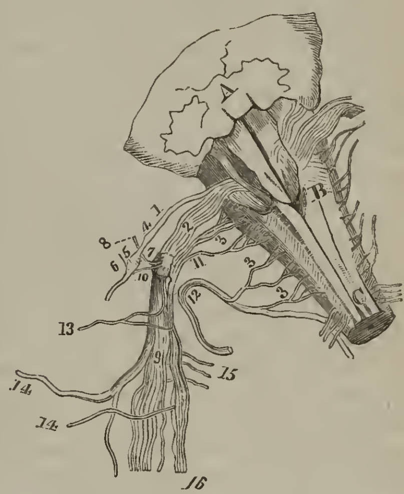


Diagram from Bendz of the ganglia and communications of the divisions of the eighth pair. A. Cerebellum. B. Medulla oblongata. C. Spinal cord. 1. Root of glosso-pharyngeal nerve. 2. Roots of vagus. 3. Roots of spinal accessory. 4. Jugular ganglion. 5. Petrous ganglion. 6. Tympanic branch. 7. Ganglion of the root of the vagus. 8. Auricular branch. 9. Ganglion of the trunk of vagus. 10. Branch from the last to the petrous ganglion. 11. Inner portion of spinal accessory. 12. Outer portion of the same. 13. Pharyngeal branch of vagus. 14. Upper laryngeal branch. 15. Branches to the sympathetic. 16. Fasciculus of spinal accessory prolonged with vagus.

The *upper ganglion* or ganglion of the root of the pneumogastric nerve* (gang. superius v. radicis nervi vagi) fig. 361,[7], is situate in the foramen lacerum. It is of a grayish colour, and resembles the ganglion on the posterior root of a spinal nerve. This body is nearly circular, and about two lines in diameter; it has connecting filaments with other nerves,—viz., with the facial, the

* These ganglia have been described particularly by Bendz.—See "*Tractatus de Connexu inter Nervum Vagum et Accessorium Willisii.*" Hen. Car. Bang Bendz. Hauniæ, 1836.—Either the one or the other ganglion had been previously noticed by the greater number of anatomists.

petrous ganglion of the glosso-pharyngeal, the spinal accessory, and the sympathetic.

The *lower ganglion*, (or ganglion of the trunk of the pneumogastric nerve,*) (ganglion inferius v. trunci nervi vagi), fig. 361,[9], is about half an inch below the preceding. Occupying the trunk of the nerve outside the skull, it is of a cylindrical form and reddish colour, and measures about ten lines in length and two in breadth. The ganglion does not include all the fibres of the nerve; the fasciculus, which is sent from the spinal accessory to join the vagus, is the part not involved in the ganglionic substance. It communicates with the spinal accessory, the hypoglossal, the spinal, and sympathetic nerves.

The pneumogastric nerves in the thorax.—In the chest the pneumogastric nerves supply branches to the lungs and heart, and are then continued through the cavity along the œsophagus to the stomach. As there is some difference between the nerves of opposite sides in this part of their course, a separate notice of each becomes necessary.

The *right* pneumogastric nerve is inclined by the side of the trachea to the back of the root of the lung, where it spreads out in a plexus (posterior pulmonary). From the lower part of the plexus two large cords, the continuation of the nerve, are directed to the œsophagus, on which they subdivide, and, with similar branches of the nerve of the left side, form the œsophageal plexus. Near the lower part of the œsophagus these branches are collected on each side into a single cord; and this cord on the left side is placed on the fore part of the œsophagus, while it is behind that tube on the right side. In this manner the trunks of both nerves are continued into the abdomen.

The nerve of the *left side*, which is placed nearer to the fore part of the thorax than its fellow, at first lies between the left carotid and subclavian arteries, and behind the left innominate vein. Next it crosses over the arch of the aorta (round which turns the recurrent laryngeal branch), and then reaches the back part of the root of the lung. Lastly, the nerve rests on the front of the œsophagus, as before stated.

In the Abdomen:—Both pneumogastric nerves enter the abdomen with the œsophagus, and are distributed to the surfaces of the stomach, the left nerve spreading on the fore part, and the right on the posterior aspect of that organ. Offsets are also given to plexuses of the sympathetic: from the right nerve one to the cœliac plexus, and from the left another to the left hepatic plexus.

BRANCHES OF THE PNEUMOGASTRIC NERVE.

Some of the branches serve to connect the pneumogastric with other nerves, and other branches are distributed to the muscular substance or the mucous lining of the organs which the nerve supplies. The principal connecting branches of this nerve are derived from the ganglia. In the different stages of its course, branches are supplied to

* This ganglion was named *superior laryngeal* by Sir Astley Cooper, from the supposition that it was the special ganglion of the superior laryngeal nerve, and that it bestowed sensory powers on that nerve.—See a paper in "*Guy's Hospital Reports*," No. 5. Oct. 1837. London.

various organs as follows :—In the jugular foramen, a branch is given to the ear; in the neck, branches are successively furnished to the pharynx, the larynx, and the heart; and in the thorax, additional branches are distributed to the heart, and others to the lungs and the œsophagus. The terminal branches in the abdomen have been already indicated.

CONNECTING BRANCHES AND AURICULAR BRANCH.

1. *Connexions between the upper ganglion of the vagus nerve and the spinal accessory, glosso-pharyngeal, and sympathetic nerves.*—The connexion with the spinal accessory is effected by one or two filaments. The filament to the petrous ganglion of the glosso-pharyngeal is directed transversely; it is not always present. The communication with the sympathetic is established by means of the ascending offset of the upper cervical ganglion.

2. The *auricular branch* connects the pneumogastric with the facial nerve in the petrous substance of the temporal bone, and is then continued to the pinna of the ear. Arising from the ganglion of the root, this branch is joined by a filament from the glosso-pharyngeal nerve; it then turns backwards along the outer boundary of the jugular foramen to an opening near the styloid process. Next, it traverses the substance of the temporal bone, crossing the aqueduct of Fallopius, about two lines from its lower end, and, reaching the surface between the mastoid process and the external auditory meatus, is distributed to the integument of the back of the ear. In the bone the auricular branch is connected with the facial nerve (which it crosses), and on the surface it joins with an offset of the posterior auricular branch of the same nerve.

3. *Connexions of the second ganglion of the vagus with the spinal accessory, hypoglossal, sympathetic, and spinal nerves.*—Independently of its connexion with the inner division of the spinal accessory, which becomes part of the pneumogastric nerve, this ganglion is connected by filaments with the trunk of the hypoglossal, with the upper cervical ganglion of the sympathetic, and with the loop formed between the first two cervical nerves.

BRANCHES FOR THE PHARYNX, LARYNX, AND HEART.

1. Pharyngeal Branch.

The pharyngeal branch, fig. 361, [13], arises from the upper part of the ganglion of the trunk of the nerve. In its progress inwards to the pharynx this nerve crosses, in one case over, in another under the internal carotid artery; and it divides into branches, which, conjointly with others derived from the glosso-pharyngeal, the superior laryngeal, and the sympathetic nerves, form a plexus (*pharyngeal*) behind the middle constrictor of the pharynx. From the plexus, branches are given to the muscular structure and the mucous membrane of the pharynx. As the pharyngeal nerve crosses the carotid artery, some filaments join those which the glosso-pharyngeal distributes on the same vessel.—There is sometimes a second pharyngeal branch.

2. Superior Laryngeal Branch.

This nerve, fig. 361, [14], springs from the middle of the ganglion of the trunk of the pneumogastric nerve. It is directed inwards to the larynx beneath the internal carotid artery, and divides beneath that vessel into two branches, distinguished as external and internal laryngeal, both ramifying in the structures of the larynx.

The *external laryngeal* branch, the smaller of the two divisions, at the side of the pharynx gives backwards filaments to the pharyngeal

plexus and to the lower constrictor muscle; and it is finally prolonged beneath the muscles on the side of the larynx to the crico-thyroid muscle* and the thyroid body, in which it ends. In the neck this branch joins the upper cardiac nerve of the sympathetic.

The *internal* division of the laryngeal nerve is continued to the interval between the hyoid bone and the thyroid cartilage, where it perforates the thyro-hyoid membrane with the laryngeal branch of the thyroid artery, and sends an offset to join the recurrent branch, after distributing several filaments to the mucous membrane.†

a. Branches to the mucous membrane.—Some twigs of the internal laryngeal nerve enter the mucous membrane of the pharynx, and communicate with filaments to the same part from the recurrent nerve; others are directed upwards in the arytæno-epiglottidean fold of mucous membrane to the base of the tongue, the epiglottis, and epiglottidean gland; and others are reflected downwards in the lining membrane of the larynx, extending to the chorda vocalis: these last are placed on the inner side of the laryngeal pouch.

b. The *communicating branch* to the recurrent laryngeal nerve is very slender, and lies beneath the lateral part of the thyroid cartilage, under which the junction between the two nerves takes place.

3. Recurrent Laryngeal Branch.

The recurrent or inferior laryngeal branch of the vagus nerve, fig. 360,[19], as the name expresses, has a reflex course to the larynx, but the point of departure from the vagus nerve and the connexions are not the same on both sides of the body.

The nerve on the *right side* arises at the top of the thorax, winds round the subclavian artery, and crosses beneath the common carotid and lower thyroid artery in its course to the trachea. On the *left side* the recurrent nerve is bent round the arch of the aorta at the point where the obliterated ductus arteriosus is connected with the arch, and is thence inclined upwards to the trachea.

Each nerve in its course to the larynx is placed between the trachea and œsophagus, supplying branches to both tubes; and, whilst making the turn round its vessel, each gives nerves to the deep cardiac plexus. At the lower part of the cricoid cartilage the recurrent nerve distributes muscular branches, a few offsets to the mucous membrane, and a single communicating filament.

a. The *branches* to the *mucous membrane* of the pharynx, few in number, unite in their ramifications with branches from the upper laryngeal nerve.

b. The *muscular branches* supply all the proper muscles of the larynx, except the crico-thyroid muscle, which is supplied from the upper laryngeal nerve.

c. The *communicating filament* joins the long branch of the upper laryngeal nerve beneath the side of the thyroid cartilage.

4. Cardiac Branches.

The cervical cardiac branches arise both at the upper and the lower part of the neck. The *upper branches* are small, and join the cardiac nerves of the sympathe-

* Bendz describes branches to the muscles fixed to the oblique line on the thyroid cartilage—viz., to the constrictor, sterno-thyroid, and thyro-hyoid muscles.

† A branch to the arytænoid muscle is sometimes described. It is difficult to say whether the nerve supplies that muscle, but it appears to do so. A branch enters the muscle, some filaments seem to end in it, and others proceed through it to the mucous membrane.

tic. The *lower*, a single branch, arises as the pneumogastric nerve is about to enter the chest. On the right side this branch lies by the side of the innominate artery, and joins one of the cardiac nerves destined for the deep cardiac plexus; it gives some filaments to the coats of the aorta. The branch of the left pneumogastric crosses the arch of the aorta, and ends in the superficial cardiac plexus.

BRANCHES IN THE CHEST AND ABDOMEN.

1. Cardiac Branches.

The thoracic cardiac branches of the right side leave the trunk of the pneumogastric, as this nerve lies by the side of the trachea; they pass inwards on the air-tube, and end in the deep cardiac plexus. The corresponding branches of the left side come from the left recurrent laryngeal nerve.

2. Pulmonary Branches.

Two sets of pulmonary branches are distributed from the pneumogastric nerve to the lung; and they reach the root of the lung, one on its fore part, the other on its posterior aspect. The *anterior* pulmonary nerves, two or three in number, are of small size. They join with filaments of the sympathetic continued on the pulmonary artery, and with these nerves constitute the *anterior pulmonary plexus*. Behind the root of the lung the pneumogastric becomes flattened, and gives several branches (of much larger size than the anterior branches), which, with filaments derived from the third and fourth thoracic ganglia of the sympathetic, form the *posterior pulmonary plexus*. Offsets from the last-named plexus extend along the ramifications of the air-tube through the substance of the lung.

3. Œsophageal Branches.

The œsophagus within the thorax receives branches from the pneumogastric nerves, both above and below the pulmonary branches. The latter are the larger, and are derived from the *œsophageal plexus* (plexus gulæ). This plexus is formed by connecting cords between the nerves of the right and left sides, while they lie in contact with the œsophagus.

4. Gastric Branches.

The branches distributed to the stomach (*gastric nerves*) are the terminal branches of both pneumogastric nerves. The nerve of the left side, on arriving, guided by the œsophagus, opposite the cardiac orifice of the stomach, divides into many branches: some of these extend over the fore part of the stomach; others lie along its small curvature, and unite with branches of the right nerve and the sympathetic; and filaments are continued between the layers of the small omentum to the left hepatic plexus. The right pneumogastric nerve distributes branches to the posterior surface and the cardiac end of the stomach; and a part of this nerve is continued from the stomach to the left side of the cœliac plexus of the sympathetic.

Summary.—The pneumogastric nerves supply branches to the upper part of the alimentary canal, viz., the pharynx, œsophagus, and stomach; and to the respiratory organs, namely, the larynx, trachea, and lungs. These nerves give branches likewise to the heart and great vessels by means of their communication with the cardiac plexus. Each pneumogastric nerve is connected with the following cranial nerves—the spinal accessory, glosso-pharyngeal, facial, and hypoglossal; also, with some spinal nerves; and with the sympathetic in the neck, the thorax, and abdomen.

C. SPINAL ACCESSORY NERVE.

The spinal nerve accessory to the vagus nerve, or, as it is shortly named, the spinal accessory nerve (nervus spinalis ad par vagum accessorius, eleventh cranial nerve of Sœmmerring), fig. 361, gives a fasciculus to join the trunk of the pneumogastric, and supplies branches to the sterno-mastoid and trapezius muscles.

The place of origin of this nerve from the spinal cord and its course in the spinal canal to the cranium, where it is associated with the other parts of the eighth pair, have been already described, *ante*, p. 247. From the side of the medulla oblongata it is directed outwards to the foramen lacerum posterius, and is transmitted through that opening in the same sheath of dura mater as the pneumogastric nerve. In the foramen this nerve is connected with the ganglion of the root of the pneumogastric by one or more short filaments. After escaping from the cranium, it is concealed by the internal jugular vein, and immediately divides into two parts, one of which (the internal part) joins the vagus nerve, the other (the external one) supplies the sterno-mastoid and trapezius muscles.

The *internal or accessory division*, the smaller of the two, gets at once into contact with the vagus nerve, close to the base of the skull, and blends with that nerve beyond its second ganglion.*

The *external division* of the spinal accessory nerve is directed backwards, and after crossing the internal jugular vein, in one case over, in another under the vein, perforates the sterno-mastoid muscle, at the same time supplying it with branches, and communicating in its substance with branches of the cervical plexus. Crossing, in the next place, the neck behind the sterno-mastoid, the nerve passes beneath the trapezius muscle. Here it forms a kind of plexus with branches of the third and fourth cervical nerves, and distributes offsets to the trapezius, which extend nearly to the lower edge of the muscle. Besides the communications between the spinal accessory and the spinal nerves already mentioned, another communication is formed with branches of the cervical nerves in the interval between the two muscles to which the nerve is distributed.

NINTH PAIR OF CRANIAL NERVES.

The hypoglossal, or ninth cranial nerve (nerv. hypoglossus, par nonum,—Willis, twelfth cranial nerve,—Sœmmerring), fig. 362, is the motor nerve of the tongue.

The filaments by which this nerve arises from the medulla oblongata are collected into two bundles, which converge to the anterior condyloid foramen of the occipital bone. Each bundle of filaments perforates the dura mater separately opposite the foramen, and the two are joined after they have passed through it.

* It is stated by Bendz that a filament is given from the spinal accessory to the pharyngeal nerve above the place of junction with the vagus, and that fibrils of the same nerve have been traced into each of the muscular offsets of the pneumogastric nerve.

After leaving the cranium, this nerve descends almost vertically to the lower border of the digastric muscle, and, changing its course, is thence directed forwards above the hyoid bone, and between the muscles in this situation to the under part of the tongue.

Fig. 362.

Diagram of the trunk of the hypoglossal nerve. 1. Trunk of the nerve. 3. Descending cervical branch. 4. 5. Two nerves from the second and third cervical nerves to form the arch with the descendens noni.

As it descends from the base of the skull, the hypoglossal nerve lies at first very deeply with the vagus nerve, to which it is connected; but it gradually approaches nearer to the surface, passing between the internal carotid artery and the jugular vein. Where it curves forward towards the tongue, the nerve turns round the occipital artery, and then crosses the external carotid below the tendon of the digastric muscle. It next sinks under the mylo-hyoid muscle, lying between it and the hyoglossus, and at the inner border of the latter is connected with the gustatory nerve. Finally, it is continued in the fibres of the genio-hyoglossus muscle beneath the tongue to its point, and distributes branches upwards to the muscular substance.

The principal *branches* of this nerve are distributed to muscles on the fore part of the neck and to the tongue; a few serve to connect it with some of the neighbouring nerves. The several branches are disposed in the following manner:—

CONNEXION WITH OTHER NERVES.

1. *Connexion with the pneumogastric.*—Close to the skull the hypoglossal nerve is connected with the second ganglion of the pneumogastric by separate filaments, or both nerves are united so as to form but one mass.

2. *With the sympathetic and first two spinal nerves.*—Opposite the first cervical vertebra the nerve communicates with the upper cervical ganglion of the sympathetic, and with the loop connecting the first two spinal nerves in front of the atlas.

MUSCULAR BRANCHES.

1. Descending Branch of the Ninth Nerve.

This branch (r. descendens noni), fig. 362, leaves the ninth nerve where this turns round the occipital artery, or, it may be, higher up.* It is directed across the sheath of the carotid vessels, from the outer to the inner side, and joins about the middle of the neck in a loop with one or two branches of the cervical plexus. The convexity of this loop is turned downwards; and the connexion between the nerves is effected by means of two or more interlacing filaments, which inclose an irregularly-shaped space. From this interlacement of the nerves, filaments are continued backwards to the posterior belly of the omo-hyoid, whilst others are directed forwards to the anterior belly of the same muscle, and to the sterno-

* This nerve may be derived altogether from the pneumogastric, or from both the pneumogastric and hypoglossal nerves.

hyoid and sterno-thyroid muscles. It occasionally happens that a filament is continued to the chest, where it joins the cardiac and phrenic nerves.

It is not uncommon to find the descending branch of the ninth nerve in the sheath with the large cervical vessels, and in such cases it may be placed either over or under the vein.

2. Branches to the Tongue and Neighbouring Muscles.

Branches are distributed to the following muscles, viz., the thyro-hyoid, stylo-glossus, hyo-glossus, genio-hyoid, and genio-hyo-glossus. These branches separate from the nerve where it is contiguous to the several muscles; that for the thyro-hyoid muscle near the end of the hyoid bone before the nerve passes beneath the mylo-hyoid muscle. Lastly, the hypoglossal nerve, when arrived close to the middle of the tongue with the ranine artery, gives off several long slender branches, which pass upwards into the substance of the organ. Some of the branches join with offsets from the gustatory nerve.

Summary.—The hypoglossal nerve supplies all the muscles connected with the os hyoides, including those of the tongue, with the exception of the digastric, the mylo-hyoid and the middle constrictor of the pharynx. The sterno-thyroid muscle likewise receives its nerve from the same source.

It is connected with the following nerves, viz., pneumogastric, gustatory, some spinal nerves, and the sympathetic.

THE SPINAL NERVES.

The spinal nerves are characterized by their origin from the spinal cord and their direct transmission outward from the spinal canal in the intervals between the vertebræ. Taken together, these nerves consist of thirty-one pairs; and, like the vertebræ between which they issue from the spinal canal, they are arranged into groups named cervical, dorsal, lumbar, sacral, and coccygeal. In these groups the nerves are equal in number to the vertebræ composing the division of the column with which they are associated, but with these exceptions, namely, that eight cervical nerves are recognised, and there is usually but a single coccygeal nerve.*

Each spinal nerve springs from the spinal cord by two roots which approach one another, and, with few exceptions, join in the corresponding intervertebral foramen into a single cord; and each cord so constructed separates immediately into two divisions, one of which is destined for parts in front of the spine, the other for parts behind it.

The nerves which do not emerge from the spinal canal through intervertebral foramina, and on account of which a reservation has been made above, are the first and second cervical, the last sacral, and the coccygeal nerve. The two cervical nerves issue from the

* Among seven cases which appear to have been examined with great care, Professor Schlemm ("Observat. Neurologicæ," Berolini, 1834) found two coccygeal nerves on each side in one instance, and on one side in another case. In all the rest there was but a single coccygeal nerve on each side. The occurrence of two coccygeal nerves is, therefore, an exception to the usual arrangement.

canal over the laminæ of the vertebræ,—the first over the atlas, the second over the axis; and the other two take their course outwards through the end of the sacral canal.

The connexions of the roots of the spinal nerves with the spinal cord, and the manner in which they are disposed with reference to its investing membranes, have been treated of already (*ante*, pp. 192, 247, 250). It remains to notice the characters by which each of the two roots is distinguished, and the peculiarities they present in different sets of nerves.

THE ROOTS OF THE SPINAL NERVES.

The *posterior roots* of the nerves are distinguished from the anterior roots by their greater size, as well as by the greater thickness of the fibrils of which they are composed. But these roots are chiefly characterized by the presence of ganglia. At some distance from the spinal cord the fibrils of the posterior root of an individual nerve are aggregated into two bundles; and these swell, so to say, into the ganglionic enlargement.

Ganglia of the spinal nerves.—The spinal nerves are each furnished with a ganglion; but the first cervical or suboccipital nerve is in some cases without one. The ganglia are proportioned in size to the nerves on which they are formed. They are oval in shape, and many are partially divided or notched at the inner side, the two parts involving the bundles into which the fibrils of the posterior root have just been said to be arranged.

The ganglia are placed in the intervertebral foramina, immediately beyond the point at which the roots perforate the dura mater lining the spinal canal. From this statement those on a few nerves are to be excepted. Thus, the first and second cervical nerves, which leave the spinal canal over the laminæ of the vertebræ, have their ganglia opposite that part. The ganglion of the coccygeal nerve is placed within the canal in the sac of dura mater, and at a variable distance from the origin of the nerve; and the ganglion of the last sacral nerve, in some cases, occupies a similar position.

The *anterior roots* of the spinal nerves are, as will be inferred from what has been already stated, the smaller of the two, and are devoid of ganglionic enlargement.

The roots of the different groups of spinal nerves vary considerably in size, and some variation is likewise observable in the relative thickness of the fibrils of which they are composed.

Size.—The roots of the upper *cervical nerves* are much smaller than those of the lower nerves, the first being much the smallest. The posterior roots of these nerves exceed the anterior in size more than in the other classes of the spinal nerves, and they are likewise composed of fibrils which are considerably larger than those of the anterior roots.

The roots of the *dorsal nerves*, exception being made of the first, (which resembles the lowest cervical nerves and is associated with them in its distribution,) are of small size. and vary but slightly, or not at all, from the second to the last. The fibrils of both roots are thinly

strewed over the cord, and are slender, those of the posterior exceeding in thickness those of the anterior root in only a small degree.

The roots of the lower *lumbar*, and of the upper *sacral nerves*, are the largest of all the spinal nerves; those of the lowest sacral and the coccygeal nerve are, on the other hand, the slenderest of all. All these nerves are crowded together on the lower end of the cord. As regards the relative size of the roots of the same nerves, the anterior are the smaller, but the disproportion between the two is not so great as in the cervical nerves.

Length and direction of the nerves in the spinal canal.—The place at which the roots of the upper cervical nerves are connected with the spinal cord being nearly opposite the foramina by which they leave the canal, these roots are in consequence very short. But the distance between the two points referred to is gradually augmented from nerve to nerve downwards, so that the place of origin of the lower cervical nerves is the breadth of at least one vertebra, and that of the lower dorsal nerves about the breadth of two vertebræ above the foramina, by which they respectively emerge from the canal. Moreover, as the spinal cord extends no further than the first lumbar vertebra, the length of the roots of the lumbar, sacral, and coccygeal nerves increases rapidly from nerve to nerve, and in each case may be estimated by the distance of the foramen of exit from that point. Owing to their length and the appearance they present in connexion with the spinal cord, the aggregate of the roots of the nerves last referred to have been named the "cauda equina."*

The direction the roots take within the canal requires brief notice. The first cervical nerve is directed horizontally outwards. The roots of the lower cervical and the dorsal nerves at first descend over the spinal cord, held in connexion with it by the arachnoid, till they are arrived opposite the several intervertebral foramina, where they are directed horizontally outwards. The nerves of the cauda equina are vertical in direction.

The two roots of each of the spinal nerves unite immediately beyond the ganglion on the posterior one, and the trunk thus formed separates immediately, as already mentioned, into two divisions, anterior and posterior. To these we shall now turn attention, beginning with the latter.

Certain characters common to the posterior divisions of all the spinal nerves will first be noticed. Afterwards the arrangement peculiar to each group of nerves (cervical, dorsal, &c.), will be separately considered.

* This designation originated with a comparison made by Laurentius, who, it may be added, regarded the nervous cords which occupy the lower part of the spinal canal as a portion of the spinal cord. His words are these :—

"Medulla autem è caluariæ rotu'do et amplo foramine prodiens, primum amplissima et crassissima, sensim attenuatur, id est, medullarem substantiam amittit, non corpoream molem quam eandem ubique servat; tandem cùm ad dorsi fines peruenit, tota in funiculos et filamenta caudam fere equinam referentia absumitur."—And. Laurentius, "Histor. Humani Corporis," lib. x. cap. xii., Parisiis, 1600.

POSTERIOR DIVISIONS OF THE SPINAL NERVES.

The posterior divisions of the spinal nerves are, with few exceptions, smaller than those given to the fore part of the body. Springing from the trunk which results from the union of the roots of the nerves in the intervertebral foramina, they turn backwards, and soon divide each into two parts or branches, distinguished as *external* and *internal;* and these are distributed to the muscles and the integument behind the spine. Exceptions to this general statement respecting the division of the nerves will be found in the arrangement of the first cervical and the lower sacral nerves; the peculiarities which they present will be shown in the special description of those nerves.

POSTERIOR DIVISIONS OF THE CERVICAL NERVES.

These nerves, except the first two, are directed backwards beneath the posterior intertransverse muscle, and divide behind that muscle into the external and internal branches.

The *external branches* give only muscular offsets, and are distributed to the slender muscles prolonged to the neck from the erector spinæ, namely, the cervicalis descendens and the transversalis colli with the trachelo-mastoid. That of the second nerve is the largest of the series of the external branches, and is often united to the corresponding branch of the third; it supplies the complexus muscle, which covers it, and ends in the splenius and trachelo-mastoid muscles. The first cervical nerve has no offset, similar to the external branch of each of the other cervical nerves.

The *internal branches*, which are larger than those above described, are differently disposed at the upper and the lower parts of the neck. Excluding those of the first and second nerves, which require separate notice, they are directed inwards to the spinous processes of the vertebræ; but the branches derived from the third, fourth, and fifth nerves take that course over the semispinalis, and beneath the complexus muscle, and having reached the spines of the vertebræ, are continued outwards to the integument; while, on the other hand, the branches from the lowest three cervical nerves are placed beneath the semispinalis muscle, and end in the muscular structure without furnishing (except occasionally the sixth), any offset to the skin. The last three nerves are the smallest of the series.

The muscles supplied by the internal branches just described are the complexus, semispinalis colli, the interspinales, and the multifidus spinæ.

The *cutaneous branches*, referred to as furnished by the internal branches of some of the cervical nerves, reach the surface by the side of the spinous processes, after passing through the fibres of the complexus (or at the inner side of that muscle), and through the splenius and trapezius muscles; and then turning transversely outwards, are distributed in the integument over the trapezius muscle.

The first three cervical nerves deviate more or less from the arrangement now described, and require to be noticed individually.

PECULIARITIES IN THE POSTERIOR DIVISIONS OF CERTAIN CERVICAL NERVES.

1. Suboccipital Nerve.

The posterior division, which is the larger of the two divisions of the suboccipital nerve, emerges over the arch of the atlas, between it and the vertebral artery, to the space bounded by the larger rectus and the two oblique muscles; and after a very short course, divides into branches for the surrounding muscles. One branch descends to the lower oblique muscle, and gives a filament, which passes through the fibres of that muscle, or over it, to join the second cervical nerve; another ascends over the larger rectus muscle, supplying it and the smaller rectus; a third enters the upper oblique muscle;* and a fourth sinks into the complexus, where that muscle covers the nerve and its branches.

A *cutaneous branch* is occasionally given to the back of the head from the suboccipital nerve; it accompanies the occipital artery, and is connected beneath the integument with the great and small occipital nerves.†

2. Second Cervical Nerve.

The posterior division of the second cervical nerve is much the largest of the series. When the nerve has passed through the ligament between the arches of the vertebræ, it lies below the inferior oblique muscle (which it supplies with one or two filaments), and receives a communicating branch from the first nerve. The nerve then separates into its external and internal branches; the former of which has been noticed with the corresponding branches from the cervical nerves.

The *internal branch* of this nerve, from its size and destination named the *great occipital nerve*, is directed upwards on the lower oblique muscle, and is transmitted to the surface through the complexus and trapezius, near their cranial attachments. As soon as the nerve is free from the muscles, it is joined by an offset of the cutaneous part of the third cervical nerve; and ascending with the occipital artery, it divides into branches, which radiate over the occipital part of the occipito-frontalis muscle, some appearing to enter the muscle, and others joining the smaller occipital nerve.

An *auricular branch* is sometimes supplied to the back of the ear by the great occipital nerve, and *muscular branches* are furnished to the complexus. Whilst it is beneath the complexus, the nerve in some cases is joined by an offset from the third cervical nerve.

3. Third Cervical Nerve.

The posterior division of the *third cervical nerve* differs from the nerves below it, chiefly in this respect—viz., that in addition to a cuta-

* Asch states that this branch supplies the rectus capitis lateralis muscle. "De Primo Pare Nervorum Medullæ Spinalis," § xxxiii. in Ludwig "*Scriptores Neurologici*," vol. i.

† This nerve has occasionally been found in the dissecting-room of University College. It was first recognised by James Harrison, M.D., (Session 1839–40,) and subsequently traced more fully by Mr. E. Hearne.

neous branch to the neck, it furnishes another to the skin over the occiput, which is hence named its occipital branch.

This *occipital branch* separates from the cutaneous cervical branch beneath the trapezius, perforates that muscle, and ramifies in the integument on the lower part of the occiput, lying at the inner side of the great occipital nerve. It is connected with that nerve.

Between the posterior divisions of the first three cervical nerves a connexion is in some cases established beneath the complexus by means of communicating branches; and this communication between the nerves M. Cruveilhier has designated as "the posterior cervical plexus." The arrangement referred to can, however, scarcely be said in any case to constitute a plexus, inasmuch as the connecting cords are single, and do not furnish offsets, and, moreover, the connexion between the nerves is often altogether wanting.

POSTERIOR DIVISIONS OF THE DORSAL NERVES.

Like the posterior divisions of the other spinal nerves, these are smaller than the anterior divisions (intercostal) from the same nerves, and divide between the transverse processes of the vertebræ into internal and external branches.

The *internal branches* of the upper six nerves appear in the interval between the multifidus spinæ and the semispinalis dorsi: they supply those muscles, and become cutaneous by the side of the spinous processes of the vertebræ. The same branches of the lower six dorsal nerves are placed between the multifidus spinæ and longissimus dorsi, and end in the former muscle without giving branches to the integument.

The *external branches* increase in size from above downwards, and the lower five or six give cutaneous offsets. These external branches are directed through or beneath the longissimus dorsi to the cellular space between this muscle and the sacro-lumbalis; and they supply both those muscles, together with the small muscles by which they are continued upwards to the neck, and the levatores costarum.

The *cutaneous branches* of the dorsal nerves vary in their position, according as they are derived from the internal or the external branches above described. Those from the internal branches of the upper six nerves perforate the rhomboid and trapezius muscles close to the spines of the vertebræ, and are directed outwards in the integument; the branch from the second nerve reaches as far as the scapula. Gangliform enlargements will often be found on these nerves. The cutaneous nerves given from the external branches emanate from the lower five or six dorsal nerves, and are transmitted to the integument through the lower serratus muscle and the fleshy part of the latissimus dorsi, in a line with the angle of the ribs.

It will be observed, that where cutaneous nerves are supplied by the internal branches, there are none from the external branches of the same nerves,* and *vice versà;* and that the branches which give cuta-

* Valentin states that there are cutaneous nerves from all the external and internal branches; "Sœmmerring V. Bau," &c. While this statement is dissented from, it should be remarked that the cutaneous nerves are not always limited to the number mentioned in the text.

neous offsets are larger than those that end in muscles without reaching the skin.

POSTERIOR DIVISIONS OF THE LUMBAR NERVES.

The branches given backwards from the lumbar nerves resemble those of the lower dorsal nerves in their position between the transverse processes, and their division into internal and external branches between the multifidus spinæ and erector spinæ muscles.

The *external branches* enter the erector spinæ, and give filaments to the intertransverse muscles. From the upper three, cutaneous nerves are supplied; and from the last, a fasciculus descends to the corresponding branch of the first sacral nerve.—The *cutaneous nerves* given from the external branches of the first three lumbar nerves, pierce the fleshy part of the sacro-lumbalis, and the aponeurosis of the latissimus dorsi; they cross the crest of the ilium near the edge of the erector spinæ, and terminate in the integument of the gluteal region. One or more of the filaments may be traced as far as the great trochanter of the femur.

The *internal branches* wind backwards in grooves close to the articular processes of the vertebræ, and sink into the multifidus spinæ muscle.

POSTERIOR DIVISIONS OF THE SACRAL NERVES.

These nerves issue from the sacrum through the foramina on its posterior aspect. The first three are covered at their exit from the bone by the multifidus spinæ muscle, and they bifurcate like the posterior divisions of the other spinal nerves; but the remaining two, which are below that muscle, have a peculiar arrangement, and require separate examination.

The *internal branch of the first three* sacral nerves are small, and are lost in the multifidus spinæ muscle.

The *external branches* of the same nerves are united with one another, and with the last lumbar and fourth sacral nerves, so as to form a series of anastomotic loops on the upper part of the sacrum. These branches are then directed outwards to the cutaneous or posterior surface of the great sacro-sciatic ligament, where, covered by the gluteus maximus muscle, they form a second series of loops, and end in cutaneous nerves.*

The *cutaneous nerves* derived from the second series of loops last referred to, pierce the great gluteus muscle in the direction of a line from the posterior spine of the ilium to the tip of the coccyx. They are commonly three in number,—one is near the innominate bone, another opposite the extremity of the sacrum, and the third about midway between the other two. All are directed outwards over the great gluteal muscle.

The *last two sacral nerves* placed, as already stated, below the mul-

* In six dissections made by Mr. Ellis, the arrangement of these nerves mentioned in the text was the most frequent. The variations to which it is liable are these :—the first nerve may not take part in the second series of loops, and the fourth may be associated with them.

tifidus spinæ muscle, are smaller than those above them, and are not divided into branches like those nerves. They are connected one with the other by a loop on the back of the sacrum, and the lowest is joined in a similar manner with the coccygeal nerve: one or two small filaments from these sacral nerves are distributed behind the coccyx.

POSTERIOR DIVISION OF THE COCCYGEAL NERVE.

This division of the coccygeal nerve is very small, and separates from the anterior division of the nerve in the sacral canal. It is joined by a communicating filament from the last sacral nerve, and ends in the fibrous structure about the posterior surface of the coccyx.

ANTERIOR DIVISIONS OF THE SPINAL NERVES.

The anterior divisions of the spinal nerves are distributed to the parts of the body situated in front of the vertebral column, including the limbs. They are, for the most part, considerably larger than the posterior divisions of the nerves, and the greater size is attributable to the greater mass of muscular and other structures which they are destined to supply. These nerves spring from the trunk resulting from the union of the two roots of the spinal nerves in the intervertebral foramina, and are thence directed forwards to their destination. The first two cervical nerves deviate from this arrangement; and the sacral and coccygeal nerves have, in some degree, a peculiar disposition. The peculiarities in each of these cases will be noticed in the special description of the nerves.

The anterior branch of each spinal nerve is connected by slender filaments with the sympathetic. Lastly, the cervical, lumbar and sacral nerves form plexuses of various forms; but the dorsal nerves remain separate one from the other.

ANTERIOR DIVISIONS OF THE FIRST FOUR CERVICAL NERVES.

The four upper cervical nerves form the cervical plexus by their anterior divisions. These appear at the side of the neck, between the scalenus medius and rectus anticus major muscles; and each divides into two parts, one of which communicates with the nerve above, and the other with the nerve below. Each of these nerves is connected by a communicating filament with the first cervical ganglion, or with the cord connecting that ganglion with the second. Before the description of the plexus resulting from the intercommunication of these nerves is entered on, some peculiarities in the disposition of the first two cervical nerves must be noticed.

PECULIARITIES IN THE FIRST AND SECOND NERVES.

1. Suboccipital Nerve.

The anterior division of the first nerve runs forwards in a groove on the atlas, and bends downwards in front of the transverse process of that vertebra to join the second nerve. In this course forwards it lies beneath the vertebral artery, and at the inner side of the rectus

lateralis muscle, to which it gives a branch.* As it crosses the foramen in the transverse process of the atlas, the nerve is joined by a filament from the sympathetic; and from the arch (*loop of the atlas*) it makes in front of that process, branches are supplied to the two anterior recti muscles. Short filaments connect this part of the nerve with the pneumogastric, the hypoglossal, and the sympathetic nerves.

2. Second Cervical Nerve.

The anterior division of the second cervical nerve, beginning between the arches of the first two vertebræ, is directed forwards between their transverse processes, being placed outside the vertebral artery, and beneath the intertransverse and other muscles fixed to those processes. In front of the intertransverse muscles the nerve divides into an ascending part, which joins the first cervical nerve, and a descending part to the third.

CERVICAL PLEXUS.

The cervical plexus is formed by the first four cervical nerves, and distributes branches to some of the muscles of the neck, and to a portion of the integument of the head and of the neck. It is placed opposite the first four vertebræ, beneath the sterno-mastoid muscle, and rests against the middle scalenus muscle and the elevator of the angle of the scapula. The disposition of the nerves in the plexus is easily recognised. Each nerve, except the first, branches into an ascending and a descending part; and these are united in anastomotic loops with the contiguous nerves. From the union of the second and third nerves, superficial branches are supplied to the head and neck; and from the junction of the third with the fourth, arise the cutaneous nerves of the shoulder and chest. Muscular and communicating offsets spring from the same nerves.

The *branches* of the plexus will be separated into two sets or classes —a superficial and deep one: the former consisting of those which ramify over the cervical fascia, supplying the integument and some also the platysma; the latter comprising branches which are distributed for the most part to the muscles. Again, each of these sets admits of being subdivided into two series, according to the direction the nerves take. Thus, the superficial nerves will be subdivided into an ascending and descending series:—the deep nerves into an internal and external series.

SUPERFICIAL BRANCHES (ASCENDING SERIES).

1. Superficial Cervical Nerve.

This nerve, fig. 358, ramifies in front of the sterno-mastoid muscle. It takes origin from the second and third cervical nerves, turns forward over the sterno-mastoid about its middle, and, after perforating the cervical fascia, divides beneath the platysma myoides into two branches, which are distributed to the anterior and lateral part of the

* Valentin notices filaments distributed to the articulation of the occipital bone with the atlas, and to the mastoid process of the temporal bone.

neck. This nerve may be represented by two or more cords, the branches into which it divides when a single nerve being distinct one from the other from their commencement in the plexus.*

The *upper branch* gives an ascending offset with the external jugular vein, and communicates freely with the facial nerve (cervico-facial division); it is then transmitted through the platysma to the surface, supplies that muscle, and ramifies in the integument of the upper half of the neck on its fore part, filaments reaching as far as the lower maxilla. The *lower branch* likewise pierces the platysma, and is distributed below the preceding branch, its filaments extending as low as the sternum.

While the superficial cervical nerve ramifies over the platysma myoides, the facial nerve is beneath the muscle.—According to Valentin many anastomotic arches are formed on the side of the neck between those two nerves, as well as between the branches of the former, one with the other.

2. Great Auricular Nerve.

This nerve (n. auricularis magnus) (fig. 358,[12],) winds round the outer border of the sterno-mastoid, and is directed obliquely upwards beneath the platysma myoides, between the muscle and the fascia of the neck, to the lobe of the ear. Here the nerve gives a few small offsets to the face, and ends in auricular and mastoid branches.

The *auricular branches* are directed to the back of the external ear, on which they ramify, and are connected with the branches derived from the facial and pneumogastric nerves. One of these branches reaches the outer surface of the ear by a fissure between the anti-helix and the concha. A few filaments are supplied to the outer part of the lobule likewise.

The *mastoid branch* is united to the posterior auricular branch of the facial nerve, and ascends over the mastoid process to the integument behind the ear.

The branches of the great auricular nerve which extend to the integuments of the face pass over the parotid gland. Some slender filaments penetrate deeply through the substance of the gland, and communicate with the facial nerve.

3. Small Occipital Nerve.

The smaller occipital nerve (n. occipitalis minor) (fig. 358,[13],) varies in size, and is sometimes double. It springs from the second cervical nerve, and is directed almost vertically to the head, along the posterior border of the sterno-mastoid muscle. Having perforated the deep fascia near the cranium, the small occipital nerve is continued upwards between the ear and the great occipital nerve, and ends in cutaneous filaments which extend higher than the ear, and communicate with offsets from the larger occipital nerve, as well as with the posterior auricular branch of the facial. It appears to supply the occipito-frontalis muscle.†

From the small occipital nerve near the ear is given an *auricular branch* (ram. auricularis superior posterior), which is distributed to the upper part of the ear on its posterior aspect, and to the elevator muscle of the auricle. This auricular branch is an offset from the great occipital nerve, when the small occipital has less than its usual size.

* Valentin describes three superficial cervical nerves, which he names superior, middle, and inferior. "*Sœmmerring v. Bau*," &c.

† According to Valentin (op. cit.) the small occipital nerve gives branches to the occipito-frontalis muscle, and reaches the upper part of the head. The same anatomist further states that connexions take place between the occipital and auricular nerves, some being placed over, and some beneath the occipito-frontalis muscle.

SUPERFICIAL BRANCHES OF THE CERVICAL PLEXUS (DESCENDING SERIES).

Supraclavicular Nerves.

The descending series of the superficial nerves, fig. 358, are thus named. There are two of these nerves, or, in some cases, a greater number. They arise from the third and fourth cervical nerves, and descend in the interval between the sterno-mastoid and the trapezius muscles. As they approach the clavicle, the nerves are augmented to three or more in number, and are recognised as internal, middle and posterior.

The *inner* (sternal) branch, which is much smaller than the rest, ramifies over the inner half of the clavicle, and terminates near the sternum.

The *middle branch*, lying opposite the interval between the pectoral and deltoid muscles, distributes some offsets over the fore part of the deltoid, and others over the pectoral muscle. The latter join the small cutaneous offsets of the intercostal nerves.

The *posterior branch* (acromial) is directed outwards over the acromion and the clavicular attachment of the trapezius muscle, and ends in the integument of the upper and back part of the shoulder.

DEEP BRANCHES OF THE PLEXUS—INNER SERIES.

1. Connecting Branches.

The cervical plexus is connected near the base of the skull with the trunks of the pneumogastric, hypoglossal, and sympathetic nerves, by means of filaments intervening between these nerves and the loop formed by the first two cervical nerves in front of the atlas. (See p. 301.)

2. Muscular Branches.

a. Branches are supplied to the anterior recti muscles; they proceed from the cervical nerves close to the vertebræ, including the loop between the first two of these nerves (*ante*, page 301).

b. Other branches, two in number, are connected with the descending branch of the hypoglossal nerve (r. descendens noni), forming, with that nerve, a small plexus from which the muscles below the os hyoides are supplied (see *ante*, page 293). One of the branches is derived from the second cervical nerve, and the other from the third. Both branches cross inwards either over, or, it may be, under the internal jugular vein, (the position varying in different cases,) and unite with the branch of the hypoglossal. The junction between these nerves takes place usually in front of the sheath of the large blood-vessels; but in some cases it is within the sheath. The position, in either case, is determined by that of the branch from the hypoglossal nerve.*

3. Phrenic Nerve.

The diaphragmatic or phrenic nerve, the special nerve of the diaphragm, courses through the thorax to its destination.

It commences by two roots from the third and fourth cervical nerves, and receives usually another fasciculus from another of these nerves (the fifth). As it descends in the neck, the nerve is inclined inwards over the anterior scalenus muscle; and near the chest, it is

* M. Cruveilhier describes an interchange of fibres at the place of connexion; so that a filament of the spinal nerve is directed upwards along the branch of the hypoglossal, and *vice versâ*.

joined by a filament of the sympathetic, sometimes also by another filament derived from the fifth and sixth cervical nerves.

As it enters the thorax each phrenic nerve is placed between the subclavian artery and vein, and crosses over the internal mammary artery near its root. Through that cavity each takes nearly a straight direction, in front of the root of the lung on its own side, and along the side of the pericardium,—between this and the mediastinal part of the pleura. Near the diaphragm it divides into branches, which separately penetrate the fibres of that muscle, and then diverging one from the other, are distributed on its under surface.

The two phrenic nerves differ in their connexions at the upper part of the thorax, and somewhat in their length likewise.

The *right nerve* is placed more deeply than the left, and is at first directed along the outer side of the right innominate vein, and the descending vena cava. The *nerve* of the *left side* is a little the longer of the two, in consequence of the oblique position of the pericardium round which it winds, and also because of the diaphragm being lower on this than on the opposite side. This nerve crosses in front of the aorta, and the pulmonary artery.

Besides the terminal branches supplied to the diaphragm, each phrenic nerve gives filaments to the pericardium, and receives sometimes an offset from the union of the descendens noni with the spinal nerves.*

One or two filaments of the nerve of the right side join in a small ganglion with diaphragmatic branches of the solar plexus; and from the ganglion offsets are given to the supra-renal capsule, the left hepatic plexus, and the lower vena cava. On the left side there is a junction between the same two nerves near the openings in the diaphragm for the œsophagus and the aorta, but without the appearance of a ganglion.

DEEP BRANCHES OF THE PLEXUS—EXTERNAL SERIES.

These nerves are distributed to muscles on the side of the neck, and some are connected freely with the spinal accessory nerve.

Muscular Branches.

The *sterno-mastoid* receives a branch from the second cervical nerve. Two other branches proceed from the third nerve to the *levator anguli scapulæ;* and from the cervical nerves, as they leave the spinal canal, branches are given to the middle scalenus muscle. Further the *trapezius* has branches prolonged to it, and thus, like the sterno-mastoid, this muscle receives nerves both from the spinal accessory and the cervical plexus.

Connexion with the spinal accessory nerve.—This nerve is connected with the branches of the cervical plexus furnished to the sterno-mastoid,—in the substance of the muscle; also with the branches distributed to the trapezius,—the connexion between the nerves being beneath this muscle, and having the appearance of a plexus; and with another offset of the cervical plexus in the interval between the two muscles.

Summary of the cervical plexus.—From the cervical plexus are distributed cutaneous nerves to the back of the head, part of the ear and face, and to the anterior half of the neck. The muscles supplied from the plexus, are the sterno-mastoid, the anterior recti, the levator anguli

* Mr. Swan notices this union as occurring only on the left side.—Valentin mentions other filaments supplied by the phrenic nerve to the remains of the thymus gland, the phrenic vessels, and the anterior pulmonary plexus.

scapulæ, the trapezius, the scalenus posticus, and the diaphragm. By means of its branches the plexus communicates with the pneumogastric, spinal accessory, hypoglossal, and sympathetic nerve.

ANTERIOR DIVISIONS OF THE LOWER FOUR CERVICAL NERVES.

The anterior divisions of the four lower cervical nerves appear between the scaleni muscles, and go to form the brachial plexus. They are much larger than the corresponding divisions of the upper cervical nerves, and the manner in which they join to form the plexus is different. Each of these nerves is connected by a filament with the sympathetic,—the part of that nerve in the immediate neighbourhood of each, *i. e.*, with one of the two lower cervical ganglia, or the plexus on the vertebral artery.

BRACHIAL PLEXUS.

This large plexus, from which the nerves of the upper limb are supplied, is formed by the union of the anterior divisions of the four lower cervical and the first dorsal nerves; and it further receives a fasciculus from the last of the nerves (fourth) which go to form the cervical plexus. The plexus reaches from the lower part of the neck to the axillary space, where it terminates opposite the coracoid process of the scapula in large offsets for the supply of the limb. From the interval between the anterior and middle scaleni muscles, the nerves descend beneath the clavicle, lying at first on the outer side of the large artery (subclavian and axillary), and afterwards in more close connexion with the vessel. In the neck they have little of a plexiform arangement, but they enter into various connexions in the axilla, and to the aggregate of all, the term brachial plexus is applied.

The manner in which the nerves are disposed in the plexus is liable to some variation, but the following may be regarded as the arrangement most frequently met with. The fifth and sixth cervical are joined at the outer border of the scalenus, and then receive the seventh nerve,—the three nerves giving rise to one great cord; the eighth cervical and the first dorsal nerves are united in another cord whilst they are between the scaleni muscles: the two cords thus formed lie side by side, and at the outer side of the axillary vessels. Lastly, a third cord is produced opposite the clavicle, or a little lower than this, by the union of a fasciculus from each of the other two. The three cords of which the plexus now consists, are placed as follows:—one on the outer side of the axillary artery, one on its inner side, and one behind that vessel. The large nervous cords which constitute the plexus at its lower end are continued into the branches which supply the arm.

Branches.—The branches furnished by the foregoing nerves are numerous, and may be conveniently divided into two classes—viz., those that arise above the clavicle, and those that take origin below the bone.

A. BRANCHES ABOVE THE CLAVICLE.

The branches which arise from the nerves before their union into a plexus, end in the muscles of the shoulder and the side of the chest, with the exception of the communicating fasciculus to join the phrenic nerve.

Branch *to join the Phrenic Nerve.*—This small branch is an offset from the fifth cervical nerve; it joins the phrenic nerve on the anterior scalenus muscle.

Branches for *the Scaleni and Longus Colli Muscles.*—These nerves spring in an irregular manner from the lower cervical nerves close to their place of emergence from the vertebral foramen.

The branch for *the rhomboid muscle* arises from the fifth nerve, and is directed backwards to the base of the scapula through the fibres of the middle scalenus, and beneath the levator anguli scapulæ. It is distributed to the under surface of the rhomboid muscle, and gives sometimes a branch to the levator scapulæ.

The nerve *of the subclavius muscle*, of small size, begins in the cord which results from the union of the fifth and sixth cervical nerves. It is directed over the outer part of the subclavian artery to the under surface of the subclavius muscle. This little nerve is commonly connected with the phrenic nerve in the neck or in the chest, by means of a slender filament.

Posterior Thoracic Nerve.

The posterior thoracic nerve (external respiratory of Bell) is distributed exclusively to the large serratus muscle. Formed in the substance of the middle scalenus muscle by two roots, one from the fifth and one from the sixth nerve, it reaches the surface of that muscle, lower than the nerve of the rhomboid muscle, and is often connected with that nerve. After emerging from the scalenus muscle, the posterior thoracic nerve descends behind the brachial plexus on the outer surface of the serratus magnus, and extends nearly to the lower border of this muscle, supplying it with several branches (fig. 367).

Suprascapular Nerve.

The suprascapular nerve arises from the first cord of the plexus, and bends beneath the trapezius to the dorsal surface of the scapula, where it is placed between the muscles and the bone. Entering the supraspinous fossa of the scapula, through the notch in its upper border, (beneath the ligament which crosses the notch,) the suprascapular nerve supplies two branches to the supraspinatus, one being near the upper, the other one near the lower part of the muscle; and it is then transmitted in front of the spine of the scapula to the infraspinous fossa, where it ends in the infraspinatus muscle. In the upper fossa of the scapula, a slender *articular filament* is given to the shoulder-joint, and in the lower fossa other offsets enter the same joint and the bone (scapula).

B. BRANCHES GIVEN FROM THE BRACHIAL PLEXUS BELOW THE CLAVICLE.

These, the remaining offsets of the brachial plexus, supply muscles on the fore part of the chest, some of the muscles and integument of the shoulder, and the remainder of the upper limb.

Origin of nerves from the plexus.—The several nerves now to be described are derived from the three great cords of the plexus in this order:

From the outer cord,—the external of the two anterior thoracic nerves, the outer head of the median, and the musculo-cutaneous.

From the inner cord,—the inner of the two anterior thoracic, the internal cutaneous and ulnar, the nerve of Wrisberg, and the inner head of the median.

From the posterior cord,—the subscapular nerves, the musculo-spiral, and the circumflex.

The nerves traced to the spinal nerves.—If the fasciculi, of which the principal nerves are composed, be followed through the plexus, they may be traced to the spinal nerves named for each in the subjoined table. The higher numbers refer to the cervical nerves, the unit to the dorsal nerve:—

Subscapular from	5.6.7.8.	External cutaneous from	5.6.7.
Circumflex	5.6.7. or 5.6.7.8.1.	Ulnar nerve	5.6.7.8.1. or 7.8.1. or 8.1
Internal cutaneous	8.1.	Median nerve	5.6.7.8.1. or 5.6.7.8.
Smaller internal cutaneous	8.1.	Musculo-spiral	6.7.8.

Some difference will be found between the statements of anatomists who have investigated the point—for instance, Scarpa ("*Annotationes Anatom.*") and Kronenberg, ("*Plex. nervor. Structura et Virtutes*")—with respect to the nerves to which the branches are assigned. Such difference is, doubtless, owing to the variation which actually exists in different cases.

Anterior Thoracic Nerves.

The anterior thoracic nerves, two in number, supply the pectoral muscles. They are distinguished as external and internal.

a. The *external*, or more superficial branch, crosses inwards over the axillary artery, and terminates in the great pectoral muscle.

b. The *internal*, or deeper branch, comes forward between the axillary artery and vein to the small pectoral muscle, and is joined by a branch from the preceding. This nerve presents a plexiform division beneath the small pectoral muscle, and supplies branches to it and to the larger pectoral muscle.—The two preceding nerves are connected by a filament which forms a loop over the artery at its inner side.

Subscapular Nerves.

These nerves are three in number. They are distinguished as upper, lower, and long subscapular, and are destined for the subscapularis, teres major, and latissimus dorsi muscles.

a. The *upper* nerve, the smallest of the subscapular nerves, penetrates the upper part of the subscapular muscle. *b.* The *lower* nerve gives a branch to the same muscle at its axillary border, and ends in the teres major muscle. There is sometimes a distinct nerve for the last-named muscle. *c.* The *long subscapular* nerve, the largest of the three, runs along the lower border of the subscapular muscle to the latissimus dorsi, to which it is distributed.

Circumflex Nerve.

The circumflex or axillary nerve (fig. 364) gives both muscular and cutaneous nerves to the shoulder. At first this nerve is placed behind the axillary artery, but at the lower border of the subscapular muscle it is inclined backwards, and separates into an upper and a lower division.

The *upper division* winds around the neck of the humerus, extending to the anterior border of the deltoid muscle, which covers it. Branches are distributed to that muscle; and one or two *cutaneous filaments*, after penetrating the muscular fibres, are bent downwards, and supply the integument over the lower part of the muscle.

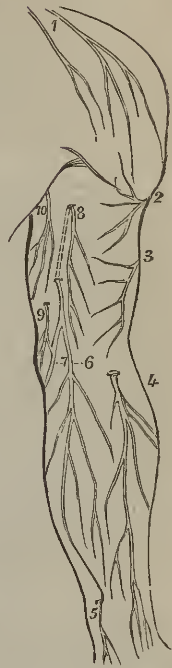
The *lower division* of the circumflex nerve supplies, near its commencement, branches to the teres minor and to the back part of the deltoid, the nerve given to the former muscle presenting a gangliform enlargement. It is then directed forwards on the cutaneous surface of the deltoid, below its middle, and after perforating the deep fascia, ramifies in the integument over the lower two-thirds of the muscle (fig. 365,[2]), one branch extending to the integument over the long head of the triceps muscle.

An *articular filament* for the shoulder-joint arises from the circumflex nerve near its commencement. It continues with the trunk of the nerve to the lower border of the scapula, and enters the capsular ligament below the subscapular muscle.

Internal Cutaneous Nerve.

At its origin from the brachial plexus, this nerve is placed on the inner side of the axillary artery. As it descends, it approaches the surface, and becomes cutaneous about the middle of the arm. After perforating the fascia—or in some cases, before it has penetrated that membrane—the internal cutaneous nerve is divided into two parts; one (the outer part) being destined for the anterior, the other for the posterior surface of the fore-arm.

Fig. 363.



Plan of the cutaneous nerves on the front of the arm. — 1. Supraclavicular nerves. 2. Branches of the circumflex nerve. 3. External cutaneous (upper branch) of the musculo-spiral nerve. 4. Musculo-cutaneous. 5. Branch of ulnar nerve. 6. Internal cutaneous: external branch. 7. Inner branch of that nerve. 8. Offset to the upper arm from same. 9. Nerve of Wrisberg. 10. Intercosto-humeral nerve.

The *external branch*, fig. 363,[6] crosses, at the bend of the elbow, over (in some cases behind) the median basilic vein. Below the elbow-joint, this branch is placed in front of the fore-arm—towards its inner side, with the cutaneous veins, and distributes filaments as far as the wrist; one of these is, in some instances, joined with a cutaneous branch of the ulnar nerve (fig. 363,[5]).

The *internal branch* of the nerve,[7] inclines obliquely downwards, at the inner side of the basilic vein, and winding to the back of the fore-arm, over the prominence of the internal condyle of the humerus, extends somewhat below the middle of the fore-arm, fig. 365.[7] Above the elbow this branch is connected with the smaller internal cutaneous nerve, (nerve of Wrisberg,) and afterwards communicates with the outer division of the internal cutaneous.*

Near the axilla the internal cutaneous gives an offset (fig. 363,[8]) through the fascia to the integument of the arm. This small branch lies a little to the outer side of the nerve from which it springs, and reaches to, or nearly to, the elbow, distributing filaments outwards to the integument over the biceps muscle. The same branch is often connected with the intercosto-humeral nerve.

Summary.—The internal cutaneous nerve gives filaments to the inner and fore part of the arm, and to the inner part of the fore arm, on the anterior and the posterior surface. Its offsets are connected with the smaller internal cutaneous nerve, and with the ulnar nerve.

Small Internal Cutaneous Nerve.

The smaller internal cutaneous nerve (nerv. cutaneus internus minor vel ulnaris Wrisbergii,—Klint,†), (fig. 363,[9]) assists the larger internal cutaneous nerve in supplying the inner side of the arm.

This nerve commonly arises from the inner cord of the brachial

* Mr. Swan describes a connexion near the wrist between this branch and the dorsal branch of the ulnar nerve.

† This nerve appears to have been first made known by Wrisberg, in his lectures; and the first published account of it is contained in an Essay by one of his pupils; see Klint, "De Nervis Brachii," in Ludwig "*Script. Nevrol. min.*" tom. iii.

plexus in connexion with the larger internal cutaneous and the ulnar nerves; but it is sometimes derived from the posterior cord of the plexus with the musculo-spiral and circumflex nerves. In the axilla, the nerve of Wrisberg is concealed at first by the axillary vein, but it soon appears on the inner side of that vessel, and communicates with the intercosto-humeral nerve. It is then placed along the inner side of the brachial vessels to about the middle of the arm, where it pierces the fascia, and is continued immediately beneath the integument to the interval between the internal condyle of the humerus and the olecranon, fig. 365,[6].

Branches.—In the lower third of the arm, branches of this little nerve are directed almost horizontally to the integument on its posterior aspect; and the nerve ends at the elbow, by dividing into several filaments, some of which are directed forwards over the inner condyle of the humerus, while others are prolonged downwards behind the olecranon.

Connexion with intercosto-humeral nerve.—The connexion between the nerve of Wrisberg and the intercosto-humeral nerve presents much variety in different cases:—in some, there are two or more intercommunications, forming a kind of plexus on the posterior boundary of the axillary space; in others, the intercosto-humeral nerve is of larger size than usual, and takes the place of the nerve of Wrisberg, only receiving in the axilla a small filament from the brachial plexus, and this small communicating filament represents in such cases the nerve of Wrisberg.

Summary.—The nerve of Wrisberg is the cutaneous nerve of the lower half of the upper arm on its inner and posterior aspect. It supplies the skin below the cutaneous branch of the musculo-spiral nerve.

Musculo-cutaneous Nerve.

The musculo-cutaneous or external cutaneous nerve (fig. 364,[5]) supplies branches to the muscles of the arm, and to the integument of the fore-arm. It is deeply placed between the muscles as far as the elbow, and below this point is immediately under the integument.

Muscular part.—Arising from the brachial plexus opposite the small pectoral muscle, this nerve perforates the coraco-brachialis muscle;* and passing obliquely across the arm between the biceps and brachialis anticus muscles, reaches the outer side of the limb a little above the elbow. Here it perforates the fascia and commences its subcutaneous course on the fore-arm, which will presently be described.

Branches.—As it descends through the arm, the nerve distributes branches to the muscles as follows:—Before it reaches the coraco-brachialis, one branch is given to that muscle and to the short head of the biceps; and other filaments are furnished to the coraco-brachialis, while the nerve lies within its fibres. Lower down, where the nerve is placed between the biceps and brachialis anticus, branches are supplied to both those muscles. Lastly, the humerus and the elbow-joint receive small filaments from the same source.

The CUTANEOUS PART of the musculo-cutaneous nerve, fig. 363,[4]

* The nerve is sometimes named "perforans Casserii," the first term of this designation having reference to the mode in which the nerve is connected with the coraco-brachialis muscle. As regards the association of the name of Casserius with the musculo-cutaneous nerve, it should be mentioned that this anatomist named the muscle "perforatus," but he does not appear to have distinguished the nerve in the manner which seems to be implied. See "Julii Casserii Placentini Tab. Anatom.:" (D. Bucretius explicat. addidit), Tab. 19 and 20. Francforti, 1632.

approaching the integument at the outer side of the biceps muscle, and nearly opposite the elbow-joint, crosses behind the median cephalic vein, and inclining outwards, divides into two branches, which supply the integument on the outer side of the fore-arm, one on its anterior, the other on its posterior aspect.

The *anterior branch* descends near the radial border of the fore-arm. It is placed in front of the radial artery near the wrist, and distributes some filaments over the ball of the thumb. Piercing then the fascia, it accompanies the artery to the back part of the carpus. This branch is connected at the wrist with an offset of the radial nerve.

The *posterior branch* of the external cutaneous nerve is directed outwards to the back of the fore-arm, and ramifies in the integument of its lower third, extending as far as the wrist, fig. 365,[10]. It communicates with a branch of the radial nerve, and with the external cutaneous branch of the musculo-spiral nerve.

Some peculiarities of the nerve.—In some cases, it does not perforate the coraco-brachialis muscle. It is from time to time found to be an offset of the median nerve; and in this case, the coraco-brachialis muscle receives a separate branch from the brachial plexus.

Summary.—The musculo-cutaneous nerve supplies three muscles in front of the humerus, and the integument on the outer side of the fore-arm. Communications are established between it and the radial and the external cutaneous branch of the musculo-spiral.

ULNAR NERVE.

The ulnar nerve, (fig. 364,[7]) supplies both muscular and cutaneous branches to the fore-arm and the hand. In its whole course it lies along the inner (ulnar) side of the limb.

At its commencement the ulnar nerve lies at the inner side of the axillary artery, and retains the same position with respect to the brachial vessels nearly to the middle of the arm. From this point it gradually inclines inwards, through the internal intermuscular septum, to the interval between the olecranon and the inner condyle of the humerus, and reaches the fore-

Fig. 364.

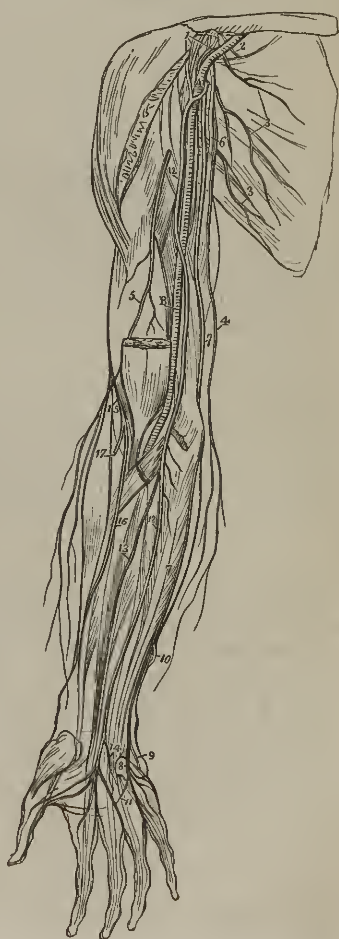


Fig. 364 A plan of the nerves of the arm. A. Axillary artery. B Brachial artery. Nerves: 2. Suprascapular. 3. Subscapular. 4. Internal cutaneous. 5. Musculo-cutaneous. 6. Circumflex. 7. Ulnar. 8. Superficial branch of the same on to the hand. 12. Median. 13. Anterior interosseous. 15. Musculo-spiral. 16. Radial. 17. Posterior interosseous.

arm between the two heads of the flexor carpi ulnaris. From the axilla to the place at which it sinks beneath the muscle last named, the nerve is covered only by the fascia, and may be felt through the integument, a little above the elbow.

In the fore-arm: The ulnar nerve extending in a straight course to the outer side of the pisiform bone of the carpus, is concealed by the flexor carpi ulnaris, as far as the middle of this part of the limb; and thence onwards, it lies at the outer side of the same muscle, covered only by the integument and fascia. In the whole course from the elbow to the carpus, it rests against the deep flexor of the fingers; and the ulnar artery, which is separated from the nerve by a considerable interval at the elbow, is in contact with it (on the outer side) in the lower half of the fore-arm.

Branches.—In its course along the upper arm the ulnar nerve gives off no branch. The offsets derived from it at the elbow and in the fore-arm, are as follows:—

1. *Articular nerves.*—These consist of some small filaments supplied to the elbow-joint, as the nerve passes close behind the joint.

2. *Muscular branches.*—One branch enters the upper part of the flexor carpi ulnaris, and another supplies the two inner divisions (the inner half) of the deep flexor of the fingers.

3. *Cutaneous branches.*—These are two small nerves that arise about the middle of the fore-arm, by a common trunk. One pierces the fascia, and turning downwards, joins a branch of the internal cutaneous nerve, fig. 363,[5]. This branch is often absent. The second, a *palmar branch*, lies on the ulnar artery, which it accompanies to the hand. This little nerve gives filaments around the vessel, and ramifies in the integument of the hand, joining in some cases with other cutaneous offsets of the ulnar or median nerve.

4. *Dorsal branch of the hand.*—This large offset, leaving the trunk of the ulnar nerve about two inches above the wrist, winds backwards beneath the flexor carpi ulnaris, and divides into branches, one of which ramifies on the inner side of the little finger, and another divides to supply the contiguous sides of that finger and the ring finger. On the back of the metacarpus, this nerve joins with an offset of the radial nerve, and from the union of the two, filaments are distributed to the opposed sides of the ring finger and the middle finger. The several posterior digital nerves now described are united with offsets directed backwards from the anterior digital nerves furnished by the median and ulnar.

Articular nerves.—Besides the foregoing branches, the ulnar nerve supplies some filaments to the wrist-joint.

Palmar part of ulnar nerve.—On the annular ligament, or somewhat beyond it, the nerve separates into two parts, one of which is superficial, and the other is deeply placed in the hand.

a. The *superficial division* accompanying the ulnar artery, supplies digital nerves at the inner side of the hand, and gives likewise a branch to the palmaris brevis muscle, and offsets to the integument.*

Digital nerves.—One of these belongs to the ulnar side of the little finger. The other is connected in the palm of the hand with a digital branch of the median nerve, and at the cleft between the little and ring fingers, gives an offset to the opposed sides of each. The disposition of the digital branches on the fingers is the same as that of the median nerve, to be presently described.

b. The *deep palmar division* of the ulnar nerve follows the course

* These may be found to communicate with the palmar nerves given from the median or ulnar.

of the deep palmar arch of vessels, beneath the long flexor tendons, and in contact with the interosseous muscles.

Branches.—At its commencement, branches leave the deep palmar nerve to supply the small muscles of the little finger. As it lies across the metacarpal bones, it distributes two branches to each interosseous space—one for the palmar, the other for the dorsal interosseous muscle; and the branches of the second and third palmar interossei supply filaments to the innermost two lumbricales muscles. Opposite the space between the thumb and the index-finger, the nerve ends in branches to the adductor pollicis, and the inner part of the flexor brevis pollicis.

Summary.—The ulnar nerve gives cutaneous filaments to the lower part of the fore-arm (to a small extent), and to the hand on its palmar and dorsal aspects. It supplies the following muscles, viz.:—the ulnar flexor of the carpus, the deep flexor of the fingers (its inner half), the short muscles of the little finger, with the palmaris brevis, the inner part of the short muscles of the thumb, and the interosseous muscles of the hand, with the two internal lumbricales. Lastly, it contributes to the supply of the elbow and wrist-joints.

MEDIAN NERVE.

This nerve, fig. 364, is placed along the middle of the limb (whence its name), and it occupies a position intermediate between the ulnar and the musculo-spiral (with the radial) nerves. Beginning by two roots (one from the outer, the other from the inner cord of the brachial plexus), which unite before the axillary artery or on its outer side, the nerve is in contact with that artery and its continuation, the brachial artery, nearly to the elbow. In this position (near the elbow-joint) it is placed at the inner side of the vessel, having crossed obliquely over it.

In the fore-arm:—The median nerve, after passing between the two heads of the pronator teres, is placed between the superficial and the deep flexor muscles of the fingers, until it arrives at the lower end of the fore-arm. Here it is for a short space covered only by the integument and the fascia, and it lies between the radial flexor of the carpus, and the superficial flexor of the fingers. Finally, the nerve leaves the fore-arm beneath the anterior annular ligament of the carpus.

Branches.—The median nerve usually gives no offset in the upper arm. In the fore-arm it distributes branches to the muscles in its immediate neighbourhood, and a single cutaneous filament. These are disposed as follows:

1. *Muscular branches.*—All the muscles on the front of the fore-arm (pronators and flexors), except the flexor carpi ulnaris and part of the deep flexor of the fingers, are supplied from the median nerve, and the several branches separate from the nerve near the elbow-joint. The branch furnished to the pronator teres often arises above the joint.

2. *Anterior interosseous nerve.*—This is the longest branch of the median nerve, and it supplies the deeper muscles of the fore-arm. Commencing at the upper part of the fore-arm, beneath the superficial flexor of the fingers, the interosseous nerve courses downward with the anterior interosseous artery on the interosseous membrane, and between the long flexor of the thumb and the deep flexor of the fingers, to the pronator quadratus muscle, in which it ends. Offsets are dis-

tributed to the two muscles between which the nerve lies in its progress downwards.

3. *Cutaneous palmar branch.*—This small nerve pierces the fascia of the fore-arm close to the annular ligament, and after crossing over that ligament, ends in the integument of the palm about its middle. It is connected with the cutaneous palmar branch of the ulnar nerve, and distributes some filaments over the ball of the thumb. The filaments last referred to communicate with offsets of the radial or the external cutaneous nerve.

The median nerve in the hand.—After passing from beneath the annular ligament of the carpus, the median nerve is covered by the palmar fascia with the integument, and rests against the tendons of flexor muscles. Somewhat enlarged, and slightly reddish in colour, it here separates into two parts of nearly equal size. One of these (the external one) supplies some of the short muscles of the thumb, and gives digital branches to the thumb and the index finger; and the second division supplies the middle finger, and in part the index and ring fingers. The branches thus indicated are distributed as follows:—

1. *Branch to muscles of the thumb.*—This short nerve subdivides for the abductor, the opponens, and the outer head of the flexor brevis pollicis muscle.—The remainder of the small mass of muscles of the thenar eminence (the part placed at the inner side of the long flexor tendon) is supplied by the ulnar nerve.

2. *Digital nerves.*—The digital nerves are five in number, and belong to the thumb, and the fingers as far as the outer side of the ring finger. As they approach the cleft between the fingers, these nerves are close to the integument in the intervals between the processes of the palmar fascia: the three external remain undivided, but the fourth and fifth bifurcate and supply each the contiguous sides of two fingers.

The *first* and *second* nerves lie along the sides of the thumb, and the former (the outer one) is connected with the radial nerve over the ball of the thumb.

The *third*, destined for the radial side of the index finger, gives a muscular branch to the first or most external lumbricalis muscle.

The *fourth* supplies the second lumbricalis, and divides into two branches for the opposed sides of the index and middle fingers.

The *fifth*, the most internal of the digital nerves, is connected with the ulnar nerve, and splits to furnish a branch each to the ring and middle fingers.

Each digital nerve divides at the end of the finger into two branches, one of which supplies the pulp on the fore part of the finger; the other ramifies beneath the nail. Branches pass from each nerve forwards and backwards to the integument of the finger: and one larger than the rest inclines backwards by the side of the first phalanx of the finger, and after joining the dorsal digital nerve, ends in the integument over the last phalanx.

Summary.—The median nerve gives cutaneous branches to the palm, and to several fingers. It supplies the pronator muscles, the flexors of the carpus, and the long flexors of the fingers (except the ulnar flexor of the carpus, and part of the deep flexor of the fingers), and likewise the outer half of the short muscles of the thumb, and two lumbricales.

Some similarity will be observed between the course and distribution of the median and ulnar nerves. Neither gives any offset in the arm. Together they supply all the muscles in front of the fore-arm and the hand, and together they supply the skin of the palmar surface of the hand, and impart tactile power to all the fingers.

MUSCULO-SPIRAL NERVE.

The musculo-spiral nerve, the largest offset of the brachial plexus, fig. 364, occupies chiefly the back part of the limb, and supplies nerves to the extensor muscles, as well as, to some extent, to the skin likewise.

At its commencement, this nerve is placed behind the axillary vessels. In its progress downwards it winds in a spiral manner (whence the distinctive name) from the inner to the outer side of the limb behind the humerus, between it and the triceps muscle. On the outer side of the arm the nerve descends in the interval between the supinator longus and brachialis anticus muscles, to the outer condyle of the humerus, where it ends by dividing into the radial and posterior interosseous nerves.

The branches given from the musculo-spiral nerve in its course through the upper arm, are found on the inner side of the humerus, behind that bone, and on its outer side.

a. Internal branches.—These consist of muscular and cutaneous branches :—

1. *Muscular branches* for the inner and middle heads of the triceps. That for the inner division of the muscle is long and slender; it lies by the side of the ulnar nerve, and reaches as far as the lower third of the upper arm.

2. The *internal cutaneous* branch of the musculo-spiral nerve, fig. 365,[3], commonly unites in origin with the preceding. It winds backwards beneath the intercosto-humeral nerve, and after supplying offsets to the skin, ends about two inches from the olecranon; in some bodies it extends as far as the olecranon. This nerve is accompanied by a small cutaneous artery.

b. Posterior branches. — Whilst the musculo-spiral nerve is between the triceps muscle and the humerus, it gives off a large fasciculus, which subdivides into muscular branches.—These *muscular branches* supply the outer head of the triceps muscle and the anconeus. The *branch* of the *anconeus* is remarkable for its length, being, at the same time, slender; it descends in the substance of the triceps, to the interval between the outer condyle of the humerus and the olecranon, to terminate in the muscle for which it is destined.

c. External branches.—This series comprises branches to muscles and long cutaneous branches.—1. *The Muscular branches,* supply the supinator longus, extensor carpi radialis longior, (the extensor carpi radialis brevior receiving its nerve from the posterior interosseous,) and in most cases the brachialis anticus.

Fig. 365.

Fig. 365. Plan of the cutaneous nerves of the back of the arm and fore-arm. 1. Supra-acromial branches of the cervical plexus. 2. Cutaneous branches of the circumflex nerve. 3. Internal cutaneous of the musculo-spiral. 4. Intercosto-humeral branches. 5. External cutaneous (inferior) of the musculo-spiral. 6. Ending of the nerve of Wrisberg. 7. Part of the internal cutaneous for the back of the fore-arm. 8. Offset from the dorsal branch of the ulnar nerve. 9. Radial nerve. 10. Branch of the musculo-cutaneous for the back of the fore-arm.

2. *External cutaneous branches.*—These are two in number, and are disposed as follows:—

The *upper branch*, the smaller of the two, fig. 363,[3], is directed downwards to the fore part of the elbow, along the cephalic vein, and distributes filaments to the lower half of the upper arm, on its anterior aspect. The *lower branch* extends as far as the wrist, fig. 365,[5], distributing offsets to the lower half of the arm, and to the fore-arm, on their posterior aspect. It appears beneath the integument at the outer side of the arm, about its middle, and passes to the fore-arm over the outer side of the bend of the elbow. About the middle of the fore-arm it turns from the outer to the posterior aspect of the limb, and is connected near the wrist with a branch of the external cutaneous nerve.

Of the two nerves which result from the division of the musculo-spiral, one, the radial, is altogether a cutaneous nerve, and the other (posterior interosseous) is the muscular nerve of the back of the fore-arm.

A. RADIAL NERVE.

The radial nerve, after separating from the musculo-spiral, is placed in front of the fore-arm, close to its outer side, and afterwards turning backwards, is distributed to the integument of the back of the hand. At first it is concealed by the long supinator muscle, and lies a little to the outer side of the radial artery. This position beneath the supinator is retained to about three inches from the lower end of the radius, where the nerve turns outwards beneath the tendon of that muscle, and becomes subcutaneous. Now it separates into two branches, which ramify in the integument over the dorsal aspect of the thumb and the next two fingers, in the following manner:

Branches.—One branch, the *external* one, extends to the radial side of the thumb, and is joined by a branch of the external cutaneous nerve. It distributes filaments over the ball of the thumb.

The *internal division* of the radial nerve communicates with a branch of the external cutaneous nerve on the back of the fore-arm, and on the hand joins in an arch with the dorsal branch of the ulnar nerve. It then divides into digital nerves for the outer fingers,—*Dorsal digital nerves.* One of these ramifies on the ulnar side of the thumb, and the second on the radial side of the index finger. The third divides between the opposed sides of the index and middle fingers; and the fourth between the middle and ring fingers. This last branch is connected with a branch of the ulnar nerve. On the sides of the fingers the posterior digital nerves now described join offsets sent backwards from the palmar digital nerves.

B. POSTERIOR INTEROSSEOUS NERVE.

This nerve, the larger of the two divisions of the musculo-spiral nerve, winds to the back of the fore-arm through the fibres of the supinator brevis muscle, and is prolonged between the deep and superficial layers of the extensor muscles to the interosseous membrane, which it approaches about the middle of the fore-arm.

Much diminished in size by the separation of numerous branches for the muscles, the nerve at the lower part of the fore-arm lies beneath the extensor of the last phalanx of the thumb and the tendons of the common extensor of the fingers, and terminates on the back of the carpus in a gangliform enlargement. From this body filaments are given to the ligaments and articulations on which it rests.

The *branches* of the interosseous nerve enter the surrounding muscles, viz., the

extensor carpi radialis brevior and supinator brevis, the superficial layer of extensor muscles, except the anconeus, and the deep layer of the same muscles;—that is to say, the nerve supplies the supinators and the extensors of the carpus and of the fingers, with the exception of the supinator longus and the extensor carpi radialis longior.

Summary of the musculo-spiral nerve.—The trunk of the nerve supplies the extensor muscles of the elbow-joint, and gives a filament to one of the flexors of the same joint (brachialis anticus), but this muscle receives its principal nerves from another source. Before dividing, the nerve likewise gives offsets to two muscles of the fore-arm (the long supinator, and the long radial extensor of the carpus). The posterior interosseous division distributes nerves to the remaining muscles on the outer and back part of the fore-arm (the short supinator and the extensors).

Cutaneous nerves are distributed, from the trunk of the nerve and its radial division, to the lower part of the upper arm, to the fore-arm, and to the hand—on the posterior and outer aspect of each.

ANTERIOR DIVISIONS OF THE DORSAL NERVES—INTERCOSTAL NERVES.

These nerves, fig. 367, which from their position with respect to the ribs are named *intercostal*, are twelve in number, and are distributed to the walls of the thorax and abdomen. The connecting cords with the sympathetic nerve are placed in the intercostal spaces, close to the vertebræ.

The intercostal nerves pass separately to their destination, without forming any plexus by the connexion or interlacement of their fibres, and in this respect they differ from the other spinal nerves. From the intervertebral foramina they are directed transversely across the trunk, and nearly parallel one to the other. The upper nerves, with the exception of the first, are confined to the parietes of the thorax, while the lower nerves are continued from the intercostal spaces to the muscles and integument of the abdomen. This difference in distribution constitutes the ground of the division of the intercostal nerves into two sets, between which the nerves are divided equally.

THE UPPER INTERCOSTAL NERVES.

In their course to the fore part of the chest, these nerves accompany the intercostal blood-vessels. After a short space they pass between the strata of the intercostal muscles, and, about midway between the vertebræ and the sternum, give off the lateral cutaneous branches. The nerves are now continued forwards, amid the fibres of the internal intercostal muscles as far as the costal cartilages, where they come into contact with the pleura. In approaching the sternum, they cross the internal mammary artery and the fibres of the triangularis sterni muscle. Finally, these nerves pierce the internal intercostal muscle and the greater pectoral, and end in the integument, under the name of the anterior cutaneous nerves of the thorax.

Branches.—Besides the cutaneous nerves (two sets) already indicated, many branches are distributed from the intercostal nerves to the neighbouring muscles. The several offsets require separate notice

Fig. 366.

Plan of the cutaneous nerves of the chest and abdomen (altered from a plate of M. Bourgery). *a.* Section of the arm. *b.* Pectoral muscle. *c.* Latissimus dorsi. *d.* External oblique. *e.* Serratus magnus. 1, 1, 1. Anterior cutaneous nerves of the chest and belly. 2, 2, 2. Anterior branches of the lateral cutaneous nerves of the chest and belly. 3, 3, 3. Posterior branches of the same. 4, 4, 4. Cutaneous branches from the posterior divisions of the lumbar nerves. 5. Ilio-hypogastric. 6. Small occipital nerve.

a. The *lateral cutaneous nerves of the thorax*, fig. 366, pierce the external intercostal and serratus magnus muscles in the same line, a little behind the level of the great pectoral muscle. Each of these nerves, except that from the second intercostal, (the first intercostal nerve has already been excluded from the general account of these nerves,) divides into two branches, which reach the integument at the same time, or at a short distance one from the other, and take opposite directions, one forward, the other backward, and hence are named anterior and posterior.

The *anterior branches*, [2], are continued forwards to where the cutaneous nerves, reflected outwards from the fore part of the thorax, end. Several of these branches reach the mammary gland and the nipple; and from the lower nerves offsets are supplied to the digitations of the external oblique muscle of the abdomen.

The *posterior branches*, [3], turn backwards to the integument over the scapula and the latissimus dorsi muscle. That derived from the second intercostal nerve is the largest of these branches, and ends in the skin of the arm; it will be presently noticed under the name "intercosto-humeral nerve." The branch from the third nerve ramifies in the axillary space, and a few filaments likewise reach the arm.

b. The *anterior cutaneous nerves of the thorax*,[1] (reflected nerves, — A. Cooper,) which are the terminal twigs of the intercostal nerves, are reflected outwards in the integument over the great pectoral muscle. The branch from the second nerve is connected with the supraclavicular and the lateral cutaneous nerves; those from the third and fourth nerves are distributed to the mammary gland.

c. Muscular branches.—Numerous filaments, which are usually slender and of various lengths, are supplied to the intercostal muscles, and the triangularis sterni. At the anterior part of the chest, some of these branches cross the cartilages of the ribs, passing from one intercostal space to another.

PECULIARITIES OF CERTAIN DORSAL NERVES.

1. First Dorsal Nerve.

The anterior division of this nerve enters almost wholly into the brachial plexus. Usually it does not supply a lateral cutaneous branch; but when that ordinarily given from the second dorsal nerve (intercosto-humeral nerve) is wanting, a branch from the first takes its place. Before emerging from the thorax to join the brachial plexus, this nerve gives off a small *intercostal branch*, which courses along the first intercostal space, in the manner of the other intercostal nerves. From this branch is derived the first of the anterior cutaneous nerves of the thorax. The cutaneous nerve, however, is wanting in some cases.

2. Second Intercostal Nerve.

The second intercostal nerve differs from the rest, chiefly in the size of its lateral cutaneous branch. This branch is the largest of the series of lateral cutaneous nerves. It commonly wants the anterior division, and the posterior one is distributed to the skin of the arm, under the name intercosto-humeral nerve.

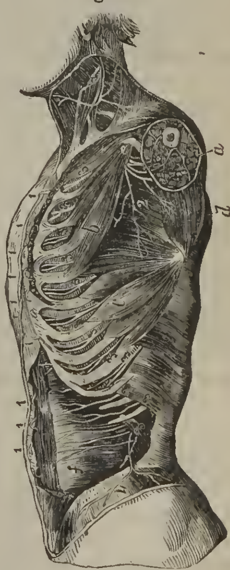
The *intercosto-humeral* nerve, proceeding from the source just indicated, crosses the axillary space to reach the arm, and is connected in the axilla with an offset of the nerve of Wrisberg. Now penetrating the fascia, it becomes subcutaneous, and ramifies in the integument of the upper half of the arm, on its inner and posterior aspect, fig. 365, [4]: a few filaments reach the integument over the scapula. The branches of this nerve cross over the internal cutaneous offset of the musculo-spiral nerve, and a communication is established between the two. —The size of the intercosto-humeral nerve (and the same may be said of the extent to which it supplies the integument) is in inverse proportion to the size of the other cutaneous nerves of the upper arm, especially the nerve of Wrisberg (see *ante*, page 310).

THE LOWER INTERCOSTAL NERVES.

The lower intercostal nerves, with the exception of the last, pass through the intercostal spaces, (fig. 367;) and in this part of their course they have the same arrangement as the nerves of the upper series. From the anterior ends of the intercostal spaces, they are continued, between the internal oblique and the transverse muscle of the abdomen, to the outer edge of the rectus. Perforating its sheath, they then enter the substance of this muscle, and terminate in small cutaneous branches (anterior cutaneous).

These nerves supply the intercostal and abdominal muscles, and they are connected one with another between the muscles of the abdomen. About the middle of their course, offsets (lateral cutaneous nerves of the abdomen) are transmitted to the integument as from the upper intercostal nerves.

Fig. 367.



a. The *lateral cutaneous nerves of the abdomen*, fig. 366, pass to the integument through the external intercostal and external oblique muscles, in a line with the corresponding nerves on the thorax, and divide in the same manner into anterior and posterior branches.

The *anterior branches* are the larger, and are directed inwards in the superficial fascia, with small cutaneous arteries, nearly to the edge of the rectus muscle.

The *posterior branches* bend backwards over

Fig. 367. Plan of the intercostal nerves, (altered from Bourgery.) *a*. Cut surface of the arm. *b*. Pectoralis minor muscle. *c*. Serratus magnus muscle. *d*. Subscapular muscle. *f*. Transverse muscle of the abdomen. 1, 1, 1, 1. Anterior cutaneous nerves of the thorax and abdomen. 2. Posterior thoracic nerve. 3, 3, 3. Intercostal nerves. 4. Lateral cutaneous branch of the last dorsal nerve.

the latissimus dorsi muscle, and extend towards the cutaneous nerves of the back.

b. The *anterior cutaneous nerves** *of the abdomen* become subcutaneous near the linea alba, with small perforating arteries. Their number and position is very uncertain. They are directed outwards towards the lateral cutaneous nerves, fig. 366.

Last Dorsal Nerve.

The anterior division of this nerve is below the last rib, and is contained altogether in the abdominal wall. The nerve has the general course and distribution of the others, between the internal oblique and transversalis, but before taking its place between those muscles, it crosses the upper part of the quadratus lumborum, and pierces the aponeurosis of the transverse muscle (lumbar fascia). This nerve is connected by offsets with the nerve above, and occasionally with the ilio-hypogastric branch of the lumbar plexus. Near the spine it sometimes communicates with the first lumbar nerve by means of a small cord (dorsi-lumbar) in the substance of the quadratus lumborum.

The *lateral cutaneous branch* of the last dorsal nerve (fig. 367, [4],) becomes subcutaneous by passing through both oblique muscles: it is then directed downwards over the crest of the ilium to the integument covering the fore part of the gluteal region and the upper and outer part of the thigh, some filaments reaching as far as the great trochanter of the femur.

ANTERIOR DIVISIONS OF THE LUMBAR NERVES.

The anterior divisions of the lumbar nerves increase in size from the first to the fifth, and all, except the fifth, besides giving off branches outwards, are connected together by anastomotic loops, so as to form the lumbar plexus. On leaving the intervertebral foramina, these nerves are connected by filaments with the sympathetic nerve, and the filaments are longer than those connected with other spinal nerves, in consequence of the position of the lumbar sympathetic ganglia,—on the fore part of the bodies of the vertebræ. In the same situation small twigs are furnished to the psoas and quadratus lumborum muscles.

The anterior division of the fifth lumbar nerve, as just stated, does not enter into the lumbar plexus. Having received a vertical branch from the nerve next above it, it descends to join the anterior division of the first sacral nerve, and thus forms part of the sacral plexus. The cord resulting from the union of a part of the fourth with the fifth nerve, is named the *lumbo-sacral* nerve.

Superior Gluteal Nerve.

Before joining the first sacral nerve, the lumbo-sacral cord gives off from behind the superior gluteal nerve, which leaves the pelvis through the large sacro-sciatic foramen, above the pyriformis muscle, and divides, like the gluteal artery, into two branches, which are distributed chiefly to the smaller gluteal muscles.

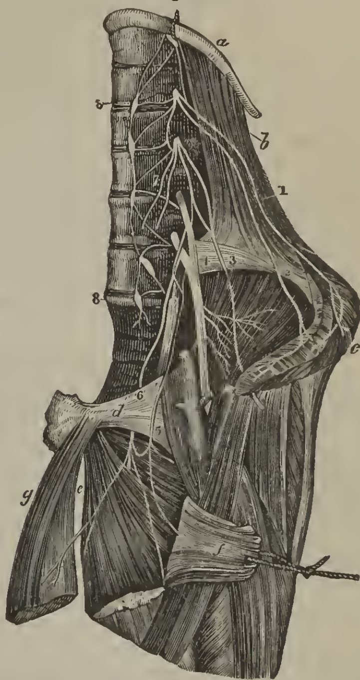
* A second set of anterior cutaneous branches is described by Professor Cruveilhier as existing at the outer edge of the rectus muscle.

The *upper* branch runs, together with the gluteal artery, along the origin of the gluteus minimus, and is lost in it, and in the gluteus medius. The *lower* branch crosses over the middle of the gluteus minimus, between it and the gluteus medius, and having supplied filaments to both these muscles, is continued forwards, and terminates in the tensor muscle of the fascia lata.

LUMBAR PLEXUS.

The lumbar plexus is formed by the connexion of the anterior divisions of the four upper lumbar nerves. It is placed in the substance of the psoas muscle, in front of the transverse processes of the corresponding vertebræ. Above, the plexus is narrow, and is sometimes connected with the last dorsal nerve by a small filament named dorsi-lumbar; below it is wider, and is joined to the sacral plexus by means of the lumbo-sacral nerve.

Fig. 368.



The lumbar plexus and its branches (slightly altered from Schmidt). *a.* Last rib. *b.* Quadratus lumborum muscle. *c.* Oblique and transverse muscles, cut near the crest of the ilium. *d.* Os pubis. *e.* Adductor brevis muscle. *f.* Pectineus. *g.* Adductor longus. 1. Ilio-hypogastric branch. 2. Ilio-inguinal. 3. External cutaneous branch. 4. Anterior crural nerve. 5. Accessory obturator. 6. Obturator nerve. 7. Genito-crural nerve divided into two at its origin from the plexus. 8. Gangliated cord of the sympathetic nerve.

The arrangement of the nerves constituting the plexus, and the mode of origin of its several branches, may be thus stated:—The first nerve gives off the ilio-hypogastric and ilio-inguinal nerves, and sends downwards a communicating branch to the second nerve. The second furnishes the genito-crural and external cutaneous nerves, and gives a connecting branch to the third nerve. From the third nerve, besides the descending branch to the fourth, two branches proceed: one of which, the larger, forms part of the anterior crural nerve; the other, a part of the obturator nerve. The fourth nerve sends two branches, which serve to complete the obturator and anterior crural nerves, and a connecting branch to the fifth nerve. The fifth, with the connecting branch just mentioned, is the lumbo-sacral nerve already described.

The *branches* of this plexus form two sets, which are distributed, one to the lower part of the wall of the abdomen, the other to the fore part and inner side of the lower limb. Among the former set are the ilio-hypogastric and the ilio-inguinal nerve, and part of the genito-crural; and to the latter belong the remaining part of the genito-crural nerve, the external cutaneous, the obturator, and the anterior crural nerves.

Ilio-hypogastric and Ilio-inguinal Nerves.

The two upper branches from the lumbar plexus, viz.—the ilio-hypogastric and ilio-inguinal (superior and middle musculo-cutaneus, —Bichat), are both derived from the first lumbar nerve, and are destined to supply nearly similar parts. They become subcutaneous by passing between and then through the broad muscles of the abdomen, and end in the integument of the groin and scrotum (or labia pudendi), as well as in that covering the gluteal muscles. In the relative size of these two nerves, a principle of compensation is observed to exist,—the extent of distribution of the one being inversely to the extent of the other.

A. The *ilio-hypogastric* nerve, fig. 368,[1], passes from within the cavity of the abdomen to its walls, in which it is placed at first between the muscles, and ends beneath the skin. Emerging from the upper part of the psoas muscle at its outer border, it runs obliquely over the quadratus lumborum to the crest of the ilium; and there perforating the transverse muscle of the abdomen, gets between that muscle and the internal oblique, and divides into an iliac and a hypogastric branch.

a. The *iliac branch* pierces the attachment of both oblique muscles, immediately above the upper border of the ilium, and is lost in the integument over the gluteal muscles,—behind the part supplied by the lateral cutaneous branch of the last dorsal nerve.

b. The *hypogastric* or *abdominal* branch, continues on between the transverse and internal oblique muscles, and is connected with the ilio-inguinal nerve near the crest of the ilium. It then perforates in succession both the oblique muscles, passing through the external oblique near the pubes, and not far from the middle line. Having become subcutaneous, this branch is distributed to the skin over the hypogastric region, fig. 370,[1].

The size of the iliac branch of this nerve varies according to that of the lateral cutaneous branch of the twelfth dorsal. The hypogastric branch is not unfrequently joined with the last dorsal nerve between the muscles, and near the crest of the ilium.

B. The *ilio-inguinal nerve*, fig. 368,[2] (inferior musculo-cutaneous, —Bichat), smaller than the preceding, with which it has a common origin from the first lumbar nerve, supplies the integument of the groin. It descends obliquely outwards over the quadratus lumborum, and then over the iliacus muscle. In this part of its course, the nerve is placed lower down than the ilio-hypogastric; and having perforated the transverse muscle, further forward than that nerve, communicates with it between the abdominal muscles, near the anterior end of the crest of the ilium. Passing through the fleshy part of the internal oblique muscle, and afterwards through the external abdominal ring, the ilio-inguinal nerve becomes subcutaneous, fig. 370,[2], and is distributed to the skin upon the groin, as well as to that upon the scrotum in the male, or the labium pudendi in the female. In its progress this nerve furnishes branches to the internal oblique muscle.

The ilio-inguinal nerve occasionally arises from the loop connecting the first and second lumbar nerves. It is sometimes small, and ends near the crest of the ilium by joining the ilio-hypogastric nerve, which in that case gives off an inguinal branch, having a similar course and distribution to the ilio-inguinal nerve, the place of which it supplies.

Genito-crural Nerve.

The genito-crural nerve (Bichat), fig. 368,[7], as its name implies, belongs partly to the external genital organs and partly to the thigh. It is derived chiefly from the second lumbar nerve, but also receives a few fibres from the connecting cord between that nerve and the first. The nerve descends obliquely through and afterwards on the fore part of the psoas muscle towards Poupart's ligament, dividing at a variable height into an internal or genital, and an external or crural branch.*

a. The *genital branch* lies upon or near the external iliac artery, and sends filaments on that vessel; then perforating the transversalis fascia, it passes through the inguinal canal with the spermatic cord, upon which it communicates with the inferior pudendal nerve, and is then lost upon the cremaster muscle. In the female it accompanies the round ligament of the uterus, and is distributed to the labium pudendi.

b. The *crural branch* descends upon the psoas muscle beneath Poupart's ligament into the thigh. Immediately below that ligament, and at the outer side of the femoral artery, it pierces the fascia lata, fig. 370,[7]; and, having become subcutaneous, supplies the skin on the upper part of the thigh, and communicates with the middle cutaneous branch of the anterior crural nerve. Whilst passing beneath Poupart's ligament, some filaments are prolonged from this nerve on to the femoral artery.†

External Cutaneous Nerve.

This nerve, fig. 368,[3], descends through the lower part of the abdomen, and ends in the integument upon the outer side of the thigh.

Commencing from the loop formed between the second and third lumbar nerves, it reaches the surface of the psoas muscle about the middle of its outer border. Thence it is directed across the iliacus muscle to the notch beneath the anterior superior spine of the ilium, where it escapes from the abdomen. Whilst passing beneath Poupart's ligament to enter the thigh, it divides into two branches of nearly equal size:—

a. One, the *posterior branch*, perforates the fascia lata, and subdivides into two or three others, which turn backwards and supply the skin upon the outer surface of the limb, from the upper border of the ilium nearly to the middle of the thigh; the highest among the branches are crossed by the cutaneous branches from the last dorsal nerve.

b. The second, or *anterior branch* of the external cutaneous nerve, is at first contained in a sheath or canal formed in the substance of the fascia lata; but, about four inches below Poupart's ligament, it enters the subcutaneous cellular tissue, and descends beneath the skin along the outer part of the front of the thigh, giving off branches in its course, and ending near the knee. The principal offsets are those springing from its outer side.

The two branches of the external cutaneous nerve communicate one with the other at the upper part of the thigh; and, in some cases, the anterior branch reaches quite down to the knee, and communicates there with the long saphenous nerve.

* This nerve often bifurcates close to its origin from the plexus, in which case its two branches perforate the psoas muscle in different places. Schmidt describes them as separate nerves, naming the genital branch, the external spermatic, and the crural branch, lumbo-inguinal.

† It is stated by Schmidt, that when the crural branch of the genito-crural nerve is large, and commences high up near the plexus, he has observed it to give off a muscular branch, which was distributed to the lower border of the internal oblique and transversalis muscles.

OBTURATOR NERVE.

The obturator nerve (internal crural), fig. 368,[6], is distributed to the adductor muscles of the thigh, and to the hip and knee-joints.

This nerve arises from the lumbar plexus by two cords or roots, one proceeding from the third and the other from the fourth lumbar nerve. Having emerged from the inner border of the psoas muscle, opposite to the brim of the pelvis, it runs along the side of the pelvic cavity above the obturator vessels, as far as the opening in the upper part of the thyroid foramen, through which it escapes from the pelvis into the thigh. Here it immediately divides into an anterior and a posterior branch, which are separated one from the other by the short adductor muscle.

The *anterior division*, placed in front of the adductor brevis and behind the pectineus and adductor longus muscles, gives some muscular offsets, and then inclines downwards to the middle of the thigh, at its inner side, where,—at the lower border of the adductor longus and still beneath the fascia—it communicates by an offset with the internal cutaneous branch of the anterior crural nerve, and with a branch of the long saphenous nerve, forming a sort of plexus. This branch of the nerve then turns outwards upon the femoral artery, and surrounds that vessel with small filaments.

Branches.—Near the thyroid membrane, the anterior division of the obturator nerve gives off an articular branch to the hip-joint. Beneath the pectineus muscle, it receives a communicating branch from the accessory nerve to the obturator, when that nerve exists; and in the same situation supplies branches to the gracilis and adductor longus muscles, and occasionally also others to the adductor brevis and pectineus.

Occasional cutaneous nerve.—In some instances the communicating offset above described is larger than usual, and is prolonged downwards as a cutaneous nerve to the thigh and leg. When thus enlarged the branch referred to, after escaping below the border of the long adductor muscle, descends along the posterior border of the sartorius to the inner side of the knee. Here it perforates the fascia, communicates with the long saphenous nerve, and extends down the inner side of the limb, supplying the skin as low as the middle of the leg.

When this cutaneous branch of the obturator nerve is present, the internal cutaneous branch of the anterior crural nerve is small, the size of the two nerves bearing an inverse proportion one to the other.

The *posterior* or *deep division* of the obturator nerve, having passed through some fibres of the external obturator muscle, crosses behind the short adductor to the fore part of the adductor magnus, where it divides into many branches, all of which enter the muscles, excepting one which is prolonged downwards to the knee-joint.

Branches.—The *muscular* branches supply the external obturator and the great adductor muscle, with also the short adductor, when that muscle receives no offset from the anterior division of the nerve.

The *articular* branch (for the knee) rests at first on the adductor magnus, but perforates the lower fibres of that muscle, and thus reaches the upper part of the popliteal space. Supported by the popliteal artery, and sending filaments around that vessel, the nerve then descends to the back of the knee-joint, and enters the articulation through the posterior ligament.*

* See a paper by Dr. A. Thomson, London Med. and Surg. Journal, No. xcv.

Accessory Obturator Nerve.

Fig. 369.

The accessory obturator nerve (nervus ad obturatorem accessorius, inconstans—Schmidt), a small and inconstant nerve,* communicates with the obturator nerve in the thigh, and is distributed to the hip-joint, fig. 368,[5].

Arising from the obturator nerve near its upper end, or from the third and fourth lumbar nerves, this accessory nerve descends beneath the fascia along the inner border of the psoas muscle, as far as the body of the pubes, beyond which it gets behind the pectineus muscle, and ends by dividing into several branches. Of these one joins the anterior branch of the obturator nerve; another penetrates the pectineus on its under surface; whilst a third enters the hip-joint with the articular artery.

This nerve is sometimes small, and ends in filaments which lie upon and perforate the fibrous capsule of the hip-joint. When it is altogether wanting, the hip-joint receives branches from the obturator nerve itself.

Summary.—The obturator nerve and its accessory give branches to the hip and knee-joints, also to the adductor muscles of the thigh, and, in some cases, to the pectineus. Occasionally a cutaneous branch descends to the inner side of the thigh, and to the inner and upper part of the leg.

ANTERIOR CRURAL NERVE.

This nerve, fig. 368,[4] supplies the muscles which extend the leg, and sends cutaneous branches to the fore part of the thigh and the inner side of the leg.

It is the largest branch of the lumbar plexus, and is derived in part from the second, but principally from the third and fourth lumbar nerves. Situated at first, like the other branches of this plexus, among the fibres of the psoas, it emerges from the outer border of that muscle near its lower part, and is then lodged between the psoas and iliacus muscles, in which position it descends beneath Poupart's ligament into the thigh.

On the thigh, fig. 369, the anterior crural nerve is placed deeply between the psoas and iliacus muscles, about half an inch to the outer side of the femoral artery, and soon becoming

Fig. 369. Plan of nerves given from the lumbar plexus to the lower limb. 1. External cutaneous nerve. 2, 3. Branches of the same. 4. Anterior crural nerve. 5, 6. Middle cutaneous. 7. Internal cutaneous (anterior portion). 8. Long saphenous nerve. 9, 10. Muscular branches. 12. Cutaneous branch of the musculo-cutaneous nerve of the leg. 13. Anterior tibial.

* Schmidt states that he found this nerve "four or five times in nine or ten bodies."—"Commentar. de Nervis lumbalibus," § xl.

flattened out, divides into two parts, of which one is anterior and furnishes cutaneous branches, while the other (the posterior, or deep part), is distributed to muscles. In some cases, it is found to divide into four instead of two parts.

Branches.—The branches given from the anterior crural nerve *within the abdomen* are few and of small size. Some supply the iliacus muscle, and one ramifies over the femoral artery.

The *iliacus* receives three or four small branches, which are directed outwards from the nerve to the fore part of the muscle.

The *nerve of the femoral artery* (nerv. arteriæ crurali proprius,—Schmidt), divides into numerous filaments upon the upper part of that vessel.—This small branch varies somewhat in its origin. It sometimes arises lower down than usual in the thigh; it may, on the other hand, be found to take origin above the ordinary position, and in this case it proceeds from the middle cutaneous nerve when that branch springs from or near the lumbar plexus. In either case, its ultimate distribution is the same as that already described.

From the principal or terminal divisions of the nerve the remaining branches take their rise as follows:—

A. From the ANTERIOR DIVISION, cutaneous branches are given to the fore part of the thigh, and to the inner side of the leg. They are the middle and internal cutaneous nerves and the long saphenous nerve. One of the muscles (the sartorius) receives its nerves from this series.

Middle Cutaneous Nerve.

Fig. 370.

The middle cutaneous nerve, fig. 370, pierces the fascia lata about three inches below Poupart's ligament, and soon divides into two branches,[4] which descend side by side beneath the integument on the fore part of the thigh to the inner side and front of the patella. These two branches give off on each side numerous offsets to the skin. After the nerve has become subcutaneous, it communicates with the crural branch of the genito-crural nerve, and also with the succeeding nerve, the internal cutaneous.

This nerve sometimes arises from the anterior crural, high up within the abdomen.

Internal Cutaneous Nerve.

The internal cutaneous nerve, fig. 370,[5] gives branches to the skin on the inner side of the thigh, and the upper part of the leg; but the extent to which it reaches depends upon the presence of the "occasional cutaneous" branch of the obturator nerve.

This nerve, lying beneath the fascia lata, de-

Fig. 370. Plan of the cutaneous nerves on the front of the thigh. 1. Ilio-hypogastric branch. 2. Ilio-inguinal branch. 3, 3. Branches of external cutaneous nerve. 4. Branches of middle cutaneous nerve. 5, 5. Internal cutaneous: the lower number refers to the anterior division of this nerve. 6. Long saphenous nerve, when become subcutaneous. 7. Crural branch of the genito-crural nerve.

scends obliquely over the upper part of the femoral artery. It divides either in front of that vessel, or at its inner side, into two branches, (one anterior, the other internal,) which pierce the fascia separately. These two branches sometimes arise as distinct offsets from the anterior division of the anterior crural nerve.

Branches of the internal cutaneous nerve.—Previously to dividing into its two ultimate branches, this nerve gives off two or three cutaneous twigs, which accompany the upper part of the long saphenous vein. The highest of these perforates the fascia near the saphenous opening, and reaches down to the middle of the thigh. The others appear beneath the skin lower down by the side of the vein: one, larger than the rest, passes through the fascia about the middle of the thigh, and extends to the knee.—In some instances, these small offsets spring directly from the anterior crural nerve, and they often communicate with each other.

The two terminal branches of the nerve are disposed as follows.

a. The *anterior branch*,[5] descending in a straight line to the knee, perforates the fascia lata in the lower part of the thigh, and afterwards runs down near the intermuscular septum, giving off filaments on each side to the skin. Finally, it is directed over the patella to the outer side of the knee, communicating, as it crosses above the joint, with a branch of the long saphenous nerve. Very often, however, it receives only a small filament from the saphenous nerve, and then takes the place of the branch usually given by the latter to the integument over the patella.

This branch of the internal cutaneous nerve sometimes lies above the fascia in its whole length. It occasionally gives off a cutaneous filament, which accompanies the long saphenous vein, and in some cases it communicates with the branch to be next described.

b. The *inner branch* of the internal cutaneous nerve descends along the posterior border of the sartorius muscle to the inner side of the knee, fig. 372,[1] where it perforates the fascia lata, and communicates by a small branch with the long saphenous nerve, which here descends in front of it. Having given off some cutaneous filaments to the lower part of the thigh on its inner side, the nerve is then continued downwards to be distributed to the skin upon the inner side of the leg.

Whilst beneath the fascia, this branch of the internal cutaneous nerve joins in an interlacement, on the inner side of the thigh, with branches of the obturator and saphenous nerves.—Where the communicating branch of the obturator nerve, just referred to, is of large size, and is continued to the skin of the leg, the internal cutaneous nerve does not reach beyond the interlacement of nerves in which it has been stated to take part; occasionally, however, a few filaments are found to reach as far as the knee.

Long Saphenous Nerve.

The long or internal saphenous nerve, fig. 369,[8], which supplies in part the skin upon the thigh and leg, is the largest of the cutaneous branches of the anterior crural nerve. In some cases it arises in connexion with one of the deep or muscular branches.

This nerve is deeply placed as far as the knee, and, in the rest of its course, is subcutaneous. In the thigh it accompanies the femoral vessels, lying at first somewhat to their outer side, but lower down approaching close to them, and passing beneath the same aponeurosis. When the vessels pass through the opening in the adductor muscle into the popliteal space, the long saphenous nerve separates from them, and is continued downwards beneath the sartorius muscle to the inner side of the knee; where, having first given off as it lies upon the inner condyle of the femur a branch which is distributed over the front of the patella, it becomes subcutaneous by piercing the fascia between the tendons of the sartorius and gracilis muscles.

Having become subcutaneous, the nerve then accompanies the long saphenous vein along the inner side of the leg down to the foot, fig. 373, [1]. The position it bears with regard to the vein is liable to variation. It may be described as descending behind the inner border of the tibia, and, about the lower third of the leg, dividing into two branches. One of these follows the margin of the tibia, and terminates near the inner ankle; whilst the other and larger branch accompanies the vein in front of the ankle, and ends in the integument on the inner side of the foot. Some filaments are found to enter the tarsal ligaments.

Branches.—*a.* About the middle of the thigh, the long saphenous nerve gives off a *communicating branch* to join in the interlacement already noticed as formed beneath the fascia lata by this nerve and branches of the obturator and internal cutaneous nerves. After it has left the aponeurotic covering of the femoral vessels, the long saphenous nerve has, in some cases, a further connexion with one or other of the nerves just referred to.

b. The branch given to the *integument in front of the patella* perforates the sartorius muscle and the fascia lata; and, having received a communicating offset from the internal cutaneous nerve, divides into many filaments, which spread out upon the fore part of the knee. Some of these descend, and are connected with other branches of the long saphenous nerve below the knee; others turn outwards, and, by uniting with branches of the middle and external cutaneous nerves, form a plexus (plexus patellæ).

In some bodies, the last-described branch is very small, and ends by joining the internal cutaneous nerve, which, in that case, supplies its place on the front of the knee-joint.

Besides the communications already mentioned, the long saphenous nerve is connected in the leg with the cutaneous branch, derived either from the internal cutaneous or obturator nerve.

B. The DEEP SERIES of the branches of the anterior crural nerve supply the muscles situated on the fore part of the thigh, and also one of those on the inner side, viz., the pectineus. They may be thus described.

Muscular Branches.

The branch to the *pectineus* muscle (which sometimes forms one of the anterior series) crosses inwards behind the femoral vessels, and enters the muscle on its anterior aspect.

The *sartorius* muscle receives three or four branches, which arise in common with the cutaneous nerves, and mostly reach the upper part of the muscle.

The *rectus* muscle receives a distinct branch on its under surface.

The nerve for the *vastus externus*, of considerable size, descends with the branches of the external circumflex artery, towards the lower part of the muscle. It gives off a long slender *articular* filament, which reaches the knee, and penetrates the fibrous capsule of the joint.

Another large branch divides into two sets, which enter the *vastus internus* and the *crureus* about the middle of those muscles. The nerve of the vastus internus (sometimes inaptly named the short saphenous nerve), before penetrating the muscular fasciculi, gives a small offset to the knee-joint. This *articular* nerve passes along the internal intermuscular septum, with a branch of the anastomotic artery, as far as the inner side of the joint, where it perforates the capsular ligament, and is directed outwards on the synovial membrane beneath the ligamentum patellæ.

Summary.—The anterior crural nerve is distributed to the skin upon the fore part and inner side of the thigh, commencing below the

terminations of the ilio-inguinal and genito-crural nerves. It also furnishes a cutaneous nerve to the inner side of the leg and foot.

All the muscles on the front and outer side of the thigh receive their nerves from the anterior crural, and one of the muscles on the inner side of the limb (the pectineus) is also in part supplied by this nerve. The tensor muscle of the fascia lata is supplied from a different source, viz., the superior gluteal nerve.

Lastly, two branches are given from the same nerve to the knee-joint.

ANTERIOR DIVISIONS OF THE SACRAL AND COCCYGEAL NERVES.

Sacral nerves.—The anterior divisions of the first four of these nerves emerge through the anterior sacral foramina, and the fifth escapes with the coccygeal nerve from the sacral canal at its end.

The first two of the sacral nerves are of large and about equal size, the others diminish rapidly, and the fifth is exceedingly slender. Like the corresponding divisions of all the other spinal nerves, the anterior divisions of the sacral nerves communicate with the sympathetic nerve; and the communicating cord is very short, the ganglia of the latter being close to the inner margin of the foramina of the sacrum.

The first four nerves (the fourth in part) contribute to form the sacral plexus. The fifth has no share in the plexus,—it ends in the perineum. The fourth and fifth nerves have therefore some peculiarities in the manner of their distribution; and, as the description will occupy but a short space, these two nerves will be noticed first, before the details of the other nerves and the numerous branches to which they give rise is followed out.

The Fourth Sacral Nerve.

Only one part of the anterior division of this nerve joins the sacral plexus; the remainder, which is nearly half the nerve, supplies branches to the viscera and muscles of the pelvis, and sends downwards a connecting filament along the side of the coccyx to the fifth nerve.

The *visceral branches* of the fourth sacral nerve are directed forwards to the lower part of the bladder, and communicate freely with branches from the sympathetic nerve. Numerous offsets are distributed to the neighbouring viscera, according to the sex; they will be described with the pelvic portion of the sympathetic nerve. The foregoing branches are, in some instances, furnished by the third sacral nerve instead of the fourth.

Of the *muscular branches*, one enters the *levator ani*, piercing that muscle on its pelvic surface; another, in some cases, penetrates the *coccygeus*, whilst a third supplies the *external sphincter* muscle of the rectum. The last branch, after passing either through the coccygeus, or between it and the levator ani, reaches the perineum, and is distributed likewise to the integuments between the anus and the coccyx.

The Fifth Sacral Nerve.

The anterior division of this, the lowest sacral nerve, runs forwards through the coccygeus muscle opposite the junction of the sacrum and the first coccygeal vertebra;* it then descends upon the coccygeus

* The nerve occasionally passes through a foramen (fifth sacral) formed between the sacrum and the coccyx.

nearly to the tip of the coccyx, where it turns backwards through the fibres of that muscle and the gluteus maximus, and ends in the integument upon the posterior and lateral aspect of the bone.

As soon as this nerve appears in front of the bone (in the pelvis), it is joined by the descending filament from the fourth nerve, and lower down by the small anterior division of the coccygeal nerve. It supplies small filaments to the coccygeus muscle.

The Coccygeal Nerve.

The anterior division of the coccygeal, or, as it is sometimes named, the sixth sacral nerve, is a very small filament. It escapes from the spinal canal at its end, pierces the sacro-sciatic ligament and the coccygeus muscle, and upon the side of the coccyx is joined with the fifth sacral nerve, partaking in the distribution of that nerve.

THE SACRAL PLEXUS.

The lumbo-sacral cord (formed as before described by the junction of the fifth and part of the fourth lumbar nerves), the anterior divisions of the first three sacral nerves and part of the fourth, unite to form this plexus. The construction of the plexus differs from that of any other of the plexuses formed by the spinal nerves. This is formed by the junction of the several constituent nerves into one broad flat cord. To the place of union the nerves proceed in different directions, the upper ones being very oblique, while the lower are nearly horizontal in their course; and, as a consequence of this difference in direction, they diminish in length from the first to the last. The sacral plexus, thus constructed, rests on the anterior surface of the pyriform muscle, opposite the side of the sacrum. It is broadest at the upper part, where the nerves join, and narrow at the lower end, where it escapes through the great sacro-sciatic foramen, and is continued into or ends in the great sciatic nerve.

Branches.—The sacral plexus supplies the larger part of the nerves of the lower limb, and furnishes some small offsets to structures connected with the pelvis. The branches are the following: — Small offsets to muscles within the pelvis (internal obturator and pyriformis); and to other muscles on the back of the pelvis (gemelli and quadratus femoris); the pudic nerve; the small sciatic nerve, and the great sciatic nerve.

Small Muscular Branches.

The small nerves supplied to muscles situated within the pelvis, and to others on its outer side, will be placed together under this head.

To *the pyriformis muscle*, one or more branches are given, either from the plexus or from the upper sacral nerves before they reach the plexus.

The *nerve of the internal obturator muscle* arises from the upper part of the plexus—from the part, therefore, which is formed by the connexion of the lumbo-sacral and the first sacral nerves. It turns behind the spine of the ischium with the pudic vessels, and is then directed forwards through the small sacro-sciatic foramen to reach the inner surface of the obturator muscle.

The *superior gemellus* receives a small branch, which arises near the pudic nerve, from the lower part of the plexus.

The little nerve which supplies *the lower gemellus* and *quadratus femoris* muscles springs from the lower part of the plexus. Concealed at first by the great sciatic nerve, it passes beneath the gemelli and the tendon of the internal obturator,—between those muscles and the capsule of the hip-joint,—and reaches the deep (anterior) surface of the quadratus. It furnishes a nerve to the lower gemellus, as well as a small articular filament to the back part of the hip-joint.

In some cases the nerve last described proceeds from the upper end of the sciatic nerve instead of the plexus; but it is usually derived from the latter source in the manner already mentioned.

Pudic Nerve.

This nerve, fig. 371, supplies the lower end of the rectum, the perineum, and in part the external genital organs. Arising from the lower part of the sacral plexus, the pudic nerve turns behind the spine of the ischium, and then passes through the small sacro-sciatic foramen, where it usually gives off an inferior hæmorrhoidal branch. It is next directed upwards and forwards along the outer part of the ischio-rectal fossa with the pudic vessels, and divides into two terminal branches; one of these is the perineal nerve, the other ends on the dorsum of the penis.

a. The *perineal nerve*, the lower and much the larger of the two divisions of the pudic nerve, lies below the pudic artery, and is chiefly expended in branches to the integument (superficial perineal). It likewise supplies offsets to several muscles and slender filaments to the corpus spongiosum urethræ; some of these latter, before penetrating the erectile tissue, run a considerable distance over its surface.

The cutaneous and muscular offsets of the perineal nerve are distributed as follows:—

The *superficial perineal* branches are two in number, and are distinguishable as posterior and anterior. The *posterior* one, which first separates from the perineal nerve, reaches the back part of the ischio-rectal fossa, and from thence turns forwards in company with the anterior branch to reach the scrotum. Whilst in the fossa, it gives filaments inwards to the sphincter ani and to the skin in front of the anus. It communicates with the anterior branch to be next noticed, as well as with the inferior pudendal branch of the small sciatic nerve and the inferior hæmorrhoidal nerve.—The *anterior* branch descends to the fore part of the ischio-rectal fossa; and, after passing forwards with the superficial perineal artery, ramifies in the skin on the fore part of the scrotum and on the surface of the penis. This branch sends small twigs to the levator ani muscle also.

In the female, both the superficial perineal branches terminate in the external labium pudendi.

The *muscular branches* given off from the perineal division of the pudic nerve generally arise by a single trunk, which is directed inwards under cover of the transversalis perinei muscle, and divides into several offsets: these are distributed among the muscles of the perineum,—viz., the transversalis perinei, erector penis, accelerator urinæ, and compressor urethræ.

b. The *dorsal nerve of the penis*, the upper division of the pudic nerve, continues in the course of the pudic artery between the layers of the deep perineal fascia, and afterwards through the suspensory ligament of the penis. It thus reaches the dorsum of the penis, along

which it passes as far as the glans, where it divides into filaments for the supply of that part. On the penis, this nerve is joined by branches of the sympathetic system, and it distributes offsets to the integument on the upper surface and sides of the organ, including the prepuce. One large branch penetrates the corpus cavernosum penis.

In the female, this division of the pudic nerve is much smaller than in the male. It takes a similar course, and ends upon the clitoris.

The *inferior hæmorrhoidal* nerve arises from the pudic nerve at the back of the pelvis, or directly from the sacral plexus. It is transmitted through the small sacro-sciatic foramen, and then descends towards the lower end of the rectum. Some of the branches of this nerve end in the external sphincter and the adjacent skin of the anus; others reach the skin in front of that part, and communicate with the inferior pudendal branch of the small sciatic nerve and with the superficial perineal nerve.

Small Sciatic Nerve.

The small sciatic nerve (nervus ischiadicus minor) is chiefly a cutaneous nerve, supplying the integument over the posterior aspect of the thigh and (to a small extent) the leg; it also furnishes branches to one muscle—the gluteus maximus.

This nerve is formed by the union of two or more nervous cords, derived from the lower part of the sacral plexus. Leaving the pelvis through the great sacro-sciatic foramen below the pyriform muscle, it descends beneath (before) the gluteus maximus, and at the lower border of that muscle comes into contact with the fascia lata, under which it continues its course downwards along the back of the limb. The nerve perforates the fascia a little below the knee, fig. 372, [3], and, thus become subcutaneous, accompanies the short saphenous vein beyond the middle of the leg. Its terminal cutaneous branches communicate with the short saphenous nerve.

The branches of the small sciatic nerve are as follows:—

The *inferior gluteal* branches.—These are given off under the gluteus maximus, and supply the lower part of that muscle.—A distinct gluteal branch commonly proceeds from the sacral plexus to the upper part of the muscle.

The principal *cutaneous branches* of the nerve escape from beneath the lower border of the gluteus maximus; they form an external and an internal set.

The *internal* branches are mostly distributed to the skin of the inner side of the thigh at its upper part. One, however, which is much longer than the rest, the *inferior pudendal* branch, turns forwards below the tuberosity of the ischium to reach the perineum. Having pierced the fascia lata, on the outer side of the ramus of that bone, the cutaneous filaments of this branch extend forward to the front and outer part of the scrotum, and communicate with the superficial perineal nerve.

In the female, the inferior pudendal branch is distributed to the external labium pudendi.

The *external* cutaneous branches, two or three in number, turn upwards in a retrograde course to the skin over the outer part of the great gluteal muscle. In some instances one takes a different course, descending and ramifying in the integuments over the outer side of the thigh nearly to the middle.

Whilst descending beneath the fascia of the thigh, the small sciatic nerve sends off some other small cutaneous filaments. One of these, arising somewhat above the knee-joint, perforates the fascia, and is prolonged over the popliteal region to the upper part of the leg.

GREAT SCIATIC NERVE.

The great sciatic nerve (nervus ischiadicus), fig. 371, [7], the largest nerve in the body, distributes offsets to the back of the thigh, and supplies the leg and the foot with their nerves.

Fig. 371.

This large nerve is the continuation of the lower end of the sacral plexus, as that escapes from the pelvis through the sacro-sciatic foramen, below the pyriformis muscle. Placed deeply at the back of the limb, the nerve reaches down below the middle of the thigh, where it divides into two large branches, named the internal popliteal and external popliteal nerves. The bifurcation of the large nerve may take place, however, at any point intermediate between the sacral plexus and the lower part of the thigh; and, occasionally, it is found to occur even within the pelvis, a portion of the pyriformis muscle being interposed between the two great parts into which the nerve divides.

At first the great sciatic nerve lies in the hollow between the great trochanter of the femur and the tuberosity of the ischium, together with the small sciatic nerve and the sciatic artery, (a branch of this artery running in the substance of the nerve.) It is here covered by the gluteus maximus, and rests on the external rotator muscles of the thigh. Lower down it is in contact, in front, with the adductor magnus, and is covered (behind) by the long head of the biceps muscle.

Branches.—In its course downwards, the great sciatic nerve supplies offsets to some contiguous parts, viz., to the hip-joint, and to the muscles at the back of the thigh.

The *articular branches* are derived from the upper end of the nerve, and enter the capsular ligament of the hip-joint, on its posterior aspect. They sometimes arise from the sacral plexus.

The *muscular branches* are given off beneath the biceps muscle; they supply the flexors of the leg, viz., the biceps, semitendinosus, and semimembranosus. A branch is likewise given to the adductor magnus.

Fig. 371. Plan of the great and small sciatic nerves. 1. Superior gluteal nerve. 2. Pudic nerve. 3 Small sciatic nerve. 5. Inferior pudendal branch. 6. Continuation of the small sciatic in the thigh. 7. Great sciatic nerve. 8. Internal popliteal nerve. 9. Posterior tibial nerve. 10, 12. Short saphenous nerve. 11. Peroneal communicating branch. 13. External popliteal or peroneal nerve.

The two large branches into which the great sciatic nerve divides are distributed to the limb from the knee downwards, one (the internal popliteal) supplying the back of the leg and the sole of the foot; while the other (external popliteal) supplies the fore part of the leg and the dorsum of the foot.

INTERNAL POPLITEAL NERVE.

The internal popliteal nerve,* fig. 371,[8], the larger of the two divisions, following the same direction as the parent trunk, continues along the back part of the thigh and through the middle of the popliteal space. It lies at first at a considerable distance from the popliteal artery (at its outer side and nearer to the surface); but, from the knee-joint downwards, is close to the vessel, and crosses over it to the inner side. The nerve is covered at first by the biceps muscle, and afterwards has the same connexions with the neighbouring parts as the popliteal blood-vessels.

Branches.—The internal popliteal nerve supplies branches to the knee-joint, to the muscles of the calf of the leg, as well as to the skin on the posterior aspect of the leg, and on the dorsum of the foot at its outer margin. They are disposed as follows:—

Articular Nerves.

The articular branches are generally three in number: two of these accompany the upper and lower articular arteries of the inner side of the knee-joint, the third follows the middle or azygos artery. These nerves pierce the ligamentous tissue of the joint.—The upper one is wanting in some cases.

Muscular Branches.

The muscular branches of the internal popliteal nerve arise behind the knee-joint, while the nerve is between the heads of the gastrocnemius muscle:—

A single branch, which soon bifurcates, supplies the two parts of the *gastrocnemius.* The small nerve of the *plantaris* muscle is derived from the branch just described, or from the main trunk (internal popliteal). The *soleus* receives a branch of considerable size, which enters the muscle on its posterior aspect after descending to it in front of the gastrocnemius. Lying deeper than the preceding branches, and arising somewhat below the joint, is the nerve of the *popliteus* muscle. It descends along the outer side of the popliteal vessels; and, after turning beneath the lower border of the muscle, enters its deep or anterior surface.

Short or External Saphenous Nerve.

The cutaneous branch of the internal popliteal nerve (ramus communicans nervi tibiei,—Jordens;† communicans tibialis,—auctor. var.) may be named as above,

* The inner division of the sciatic nerve, from its commencement to its partition at the foot, is generally described in anatomical works without any separation into parts; and the name applied by different writers to this long cord, as might be expected, varies considerably, *e. g.* "cruralis internus," or "popliteus internus,"—Winslow: "tibialis posterior,"—Haller: "sciatique poplité interne."—Sabatier: "tibieus,"—Jordens: "tibialis vel tibieus,"—Fischer, &c. One or other of the foregoing names, or some modification of them, is used by more modern writers.

As the terms "popliteal" and "tibial," which are the bases of this varied nomenclature, are adapted respectively to only a particular portion of the entire nerve, it is probably best to divide it into parts, and to apply to each part the appropriate designation. This arrangement has the advantage of a nearer correspondence with the manner of dividing the blood-vessels.

† This nerve, and the offset of the external popliteal nerve which joins it, appear to have been first named from the fact of their connexion one with the other by Jordens ("De-

Fig. 372.

because of its following very nearly the course of the short saphenous vein. It descends along the leg beneath the fascia, resting on the gastrocnemius (at first between the heads of the muscle) to about midway between the knee and the foot. Here it perforates the fascia, (fig. 372,[4],) and is usually joined by a branch from the external popliteal nerve (communicans peronei). After receiving this communicating branch, the short saphenous nerve descends beneath the integument near the outer side of the tendo-achillis in company with the short saphenous vein, and turns forward beneath the outer malleolus to end in the skin at the side of the foot and on the little toe. On the dorsum of the foot this nerve communicates with the musculo-cutaneous nerve.

In some cases, the short saphenous nerve supplies the outer side of the fourth toe, as well as the little toe. The union between the saphenous nerve and the offset of the external popliteal nerve occurs in some cases higher than usual, occasionally even at or close to the popliteal space. It sometimes happens that the communication between the nerves is altogether wanting.

Fig. 372. Plan of the cutaneous nerves on the posterior aspect of the leg. 1. Inner division of the internal cutaneous nerve. 2, 2. Branches of the long saphenous. 3. Small sciatic become cutaneous; the offset above it in a direct line is a branch of the same nerve. 4, 6. Short saphenous nerve. 5. Peroneal communicating nerve.

POSTERIOR TIBIAL NERVE.

From the lower margin of the popliteus muscle, where it assumes this designation, the nerve continues with the posterior tibial artery, lying for a short space at the inner side and afterwards at the outer side of the vessel, as far as the interval between the inner malleolus and the heel; and here it divides into the two plantar nerves (internal and external). The posterior tibial nerve, like the vessels, is covered at first by the muscles of the calf of the leg, afterwards only by the integument and fascia, and it rests against the deep-seated muscles.

Branches.—The deep muscles on the back of the leg and integument of the sole of the foot receive branches, which leave the posterior tibial nerve in its course along the leg.

a. The *muscular branches* emanate from the upper part of the nerve, either separately or by a single common trunk; and one is distributed to each of the following muscles, viz., the tibialis posticus, the long flexor of the toes, and the long

scriptio Nervi Ischiadici," Erlangæ, 1788). This manner of designating the branches in question was followed very generally by anatomical writers until late years, and it has been adopted by most neurologists,—*e. g.*, Fischer ("Descript. Anatom. Nerv. lumbalium, sacralium et extremitatum inferiorum," Lipsiæ, 1791); Bock ("Abbildungen der Rückenmarksnerven," &c., Leipzig, 1827.)

Boyer and Bichat, in their general treatises on Anatomy, have named the offset of the internal popliteal nerve "external saphenous;" and it is not uncommon to find, in modern books, this name and the older nomenclature mixed up in the following manner:—The two branches, before their junction, are named "communicating" branches of the tibial and peroneal nerves respectively; and the nerve resulting from their union is the external saphenous nerve. M. Cruveilhier, again, treats of the two branches as "tibial saphenous" and "peroneal saphenous."

flexor of the great toe. The branch which supplies the last-named muscle runs along the peroneal artery before penetrating the muscle.

b. The *plantar cutaneous* branch, furnished from the posterior tibial nerve, perforates the internal annular ligament, and ramifies in the integument at the inner side of the sole of the foot and beneath the heel.

Internal Plantar Nerve.

The internal plantar, the larger of the two nerves furnished to the sole of the foot, accompanies the internal or smaller plantar artery, and supplies the nerves to both sides of the three inner toes, and to one side of the fourth. From the point at which it separates from the posterior tibial nerve, it is directed forwards under cover of the abductor of the great toe, and divides, opposite the posterior end of the metatarsus at the interval between the muscle just named and the short flexor of the toes, into four digital branches, and at the same time communicates with the external plantar nerve.

Branches.—As the internal plantar nerve courses forwards, small offsets are supplied to the abductor pollicis and flexor brevis digitorum; and some small branches perforate the plantar fascia to ramify in the integument of the sole of the foot.

The *digital branches*, which are named numerically from within outwards, (the innermost being first, and so on,) pass from under cover of the plantar fascia behind the clefts between the toes. The first or innermost branch continues single, but the other three bifurcate to supply the adjacent sides of two toes. These branches require separate notice.

The *first* digital branch is that destined for the inner side of the great toe; it becomes subcutaneous farther back than the others, and sends off a branch to the short flexor muscle of this toe.

The *second* branch, having reached the interval between the first and second metatarsal bones, furnishes a small offset to the first lumbricalis muscle, and bifurcates some way behind the cleft between the great toe and the second to supply their contiguous sides.

The *third* digital branch corresponds with the second interosseous space, gives a slender filament to the second lumbricalis muscle, and divides in a manner similar to the second branch into two offsets for the sides of the second and third toes.

The *fourth* digital branch crosses to the third space, and is distributed to the adjacent sides of the third and fourth toes. It receives a communicating branch from the external plantar nerve.

Along the sides of the toes, cutaneous and articular filaments are given from these digital nerves; and, opposite the ungual phalanx, each gives a dorsal branch to the parts beneath the nail, and then runs on to the pulp of the toe, where it is distributed like the nerves of the fingers.

External Plantar Nerve.

The external plantar nerve completes the supply of digital nerves to the toes, furnishing therefore branches to the little toe and half the fourth; and gives a deep branch of considerable size, which is distributed to several of the short muscles in the sole of the foot.

This nerve runs obliquely forwards towards the outer side of the foot with the external plantar artery, between the flexor brevis digito-

rum and the flexor accessorius, as far as the interval between the former of these muscles and the abductor of the little toe. Here it divides into a superficial and a deep branch, having previously furnished offsets to the flexor accessorius and the abductor digiti minimi.

a. The *superficial division* separates into two digital branches, which have the same general arrangement as the digital branches of the internal plantar nerve. They are distributed thus:—

Digital branches.—One of the digital branches continues undivided, and runs along the outer side of the little toe. It is smaller than the other, and pierces the plantar fascia further back. The short flexor muscle of the little toe and the two interosseous muscles of the fourth metatarsal space receive branches from this nerve.

The larger digital branch communicates with an offset from the internal plantar nerve, and bifurcates behind the cleft between the fourth and fifth toes to supply one side of each.

b. The *deep* or *muscular* branch of the external plantar nerve dips into the sole of the foot with the external plantar artery, under cover of the tendons of the flexor muscles and the adductor pollicis, and terminates in numerous branches for the following muscles:—all the interossei (dorsal and plantar) except one or both of those in the fourth space, the two outer lumbricales, the adductor pollicis, and the transversalis pedis.

THE EXTERNAL POPLITEAL OR PERONEAL NERVE.

This nerve,* fig. 371, descends obliquely along the outer side of the popliteal space, lying close to the biceps muscle. Continuing downwards over the outer part of the gastrocnemius muscle (between it and the biceps) to the fibula below its head, the nerve turns round that bone, passing between it and the peroneus longus muscle, and then divides into the anterior tibial and the musculo-cutaneous nerves.

Some articular and cutaneous branches are derived from the external popliteal nerve before it divides.

Articular Nerves.

The articular branches, two in number, are conducted to the outer side of the capsular ligament of the knee-joint by the upper and lower articular arteries of that side. They sometimes arise together, and the upper one occasionally springs from the great sciatic nerve before its bifurcation.

From the place of division of the external popliteal nerve, a *recurrent articular* nerve ascends through the tibialis anticus muscle with the recurrent artery to reach the fore part of the knee-joint.

Cutaneous Nerves.

The cutaneous branches, two or three in number, supply the skin on the back part and outer side of the leg. The largest of these is the *peroneal communicating branch* (r. communicans peronei,—Jordens; communicans fibularis), (fig. 372, [5],) which joins about the middle of the back of the leg with the short saphenous nerve as already mentioned in the description of that nerve. In some instances, however, it continues a separate branch and reaches down to the heel.

Another cutaneous branch extends along the outer side of the leg to the middle or lower part, sending offsets both backwards and forwards, fig. 373, [2].

* "Small sciatic ramus or sciaticus externus,"—Winslow: "tibialis anterior, exterior,"—Haller: "sciatique poplité externe,"—Sabatier: "peroneus,"—Jordens; "peroneus seu popliteus externus,"—Fischer.

MUSCULO-CUTANEOUS NERVE.

The musculo-cutaneous (peroneal) nerve is the principal cutaneous nerve of the dorsum of the foot, and also supplies the muscles on the outer part of the leg. It descends between the peronei muscles and the long extensor of the toes, and reaches the surface by perforating the fascia in the lower part of the leg on its anterior aspect. As soon as the nerve becomes subcutaneous, fig. 373,[3] or even before, it divides into two branches, distinguished as external and internal. When the division occurs while the nerve is in contact with the muscles, the two branches may be found to perforate the fascia at different heights.

Fig. 373.

Plan of the cutaneous nerves on the fore part of the leg, and the dorsum of the foot. 1. Long saphenous, become subcutaneous. 2. Branches of the external popliteal. 3. Musculo-cutaneous. 4. Anterior tibial.

Whilst between the muscles, the musculo-cutaneous nerve gives its muscular branches to the peroneus longus and peroneus brevis; and, before its final division, some cutaneous offsets are distributed to the lower part of the leg.

The *internal* division of the musculo-cutaneous nerve, fig. 373, passing forwards along the dorsum of the foot, furnishes a branch to the inner side of the great toe, and other branches to the contiguous sides of the second and third toes. It also gives offsets, which extend over the inner ankle and the corresponding side of the foot. This nerve communicates with the long saphenous nerve on the inner side of the foot, and with the anterior tibial nerve between the great toe and the second toe.

The *external* division, larger than the internal one, courses over the foot towards the fourth toe, which, together with the contiguous borders of the third and fifth toes, it supplies with branches. Cutaneous nerves, derived from this branch, spread over the outer ankle and the outer side of the foot, where it is connected with the short saphenous nerve.

The dorsal digital nerves are continued on to the last phalanges of the toes.

The number of toes supplied by each of the two divisions of the musculo-cutaneous nerve is liable to vary; together, they commonly supply all the toes on their dorsal aspect, excepting the outer side of the little toe, which receives a branch from the short saphenous nerve, and the adjacent sides of the great toe and the second toe, to which the anterior tibial nerve sends a branch.

ANTERIOR TIBIAL NERVE.

The anterior tibial (interosseous nerve), like the preceding nerve, extends through the leg to the foot, and supplies muscular and cutaneous branches; but this nerve is more deeply placed, and is distributed chiefly to muscles, while the largest part of the musculo-cutaneous nerve is given to the integument.

Commencing between the fibula and the peroneus longus, the anterior tibial nerve inclines obliquely beneath the long extensor of the

toes to the fore part of the interosseous membrane, on which structure it comes into contact with the anterior tibial vessels, fig. 369; and with those vessels (having the same connexions with neighbouring parts) it descends to the front of the ankle-joint, where it divides into an external and an internal branch. The nerve first reaches the outer side of the anterior tibial artery, above the middle of the leg; and, after crossing in front of that vessel once or oftener, lies to its outer side at the bend of the ankle.

In its course along the leg, the anterior tibial nerve gives slender filaments to the muscles between which it is placed, namely, the tibialis anticus, the long extensor of the toes, and the proper extensor of the great toe.

The more *external* of the two branches which result from the division of the anterior tibial nerve, turns outwards over the tarsus beneath the short extensor of the toes; and, having become enlarged (like the posterior interosseous nerve on the wrist) terminates in branches which supply the short extensor muscle, and likewise the articulations of the foot.

The *internal branch*, continuing onwards in the direction of the anterior tibial nerve, accompanies the dorsal artery of the foot to the first interosseous space, and ends in two branches, fig. 373,[4] which supply the integument on the neighbouring sides of the great toe and the second toe on their dorsal aspect. It communicates with the internal division of the musculo-cutaneous nerve.

Summary.—The great sciatic nerve with its divisions supplies the integument of the leg, with the exception of a part which derives nerves from the small sciatic and the anterior crural nerve. It likewise supplies the muscles on the back of the thigh, and those of the leg and foot. The several joints of the lower limb receive filaments from the same nerve.

THE SYMPATHETIC NERVE.

The sympathetic system of nerves (nervus intercostalis; nerfs de la vie organique—Bichât).—The viscera generally are supplied with nerves from this system, but some organs likewise receive offsets from the cerebro-spinal system, as the lungs, the heart, and the upper and lower ends of the alimentary canal. The characters by which the sympathetic nerve is distinguished having been already pointed out, it is only necessary to say in this place that it is reddish or gray in colour, and that it is softer in texture than the cerebro-spinal nerves.

In this system three parts may be distinguished, as follows:—

a. The part which first requires notice is to be regarded as the centre of the sympathetic. It consists of two gangliated cords—or of a series of ganglia placed longitudinally, and connected by intervening cords,—situate along the fore part of the vertebral column, at the sides, for the most part, of the bodies of the vertebræ, and extending from the base of the skull to the coccyx. The two cords lie parallel

one to the other as far as the sacrum, on which bone they gradually converge, till they both terminate in a single ganglion on the coccyx. This long cord is considered divisible into parts corresponding with the divisions of the vertebral column; and thus, cervical, dorsal, lumbar, and sacral portions are recognised.

The ganglia are equal in number to the vertebræ on which they lie, except in the neck, where there are but three. These bodies are conveniently regarded as so many centres, receiving nerves, and distributing offsets to the viscera. They are severally connected with the spinal nerves in their neighbourhood by means of short cords; and each connecting cord consists of a white and a gray portion, the former proceeding from the spinal nerve to the ganglion, while the latter takes the opposite course—from the ganglion to the spinal nerve. At its upper end the gangliated cord likewise communicates with certain cranial nerves.—The cords intervening between the ganglia, like those connecting the ganglia with the spinal nerves, are compounded of a gray and a white part, the latter being continuous with the portions of spinal nerves already traced to the ganglia.

From the ganglia, or their intervening cords, offsets are given for the supply of the viscera; and these offsets follow the course of the arteries to the organs for which they are destined. Branches are likewise sent to join the large prevertebral plexuses to be presently noticed. The offsets from the ganglia partake of both kinds of nerves (the proper sympathetic and the spinal systems), the nerves or roots which join the ganglia from the spinal system, being continued onwards with others which originate in the ganglia. From this circumstance, and the facts above mentioned respecting the constitution of the gangliated cord, it follows that the so-named sympathetic nerve is composed of two forms of nerve-fibre: one of which is peculiar, and originates in the ganglia of the sympathetic system, while the other is borrowed from the cerebro-spinal nerve.*

b. The second division of the sympathetic comprises three large aggregations of nerves, or nerves and ganglia situated in front of the spine (prevertebral plexuses), and occupying respectively the thorax, the abdomen, and the pelvis. They are single or unsymmetrical, and are named respectively the cardiac, the solar, and the hypogastric plexus. These plexuses each receive branches from both the gangliated cords above noticed, and they constitute centres from which the viscera are supplied with nerves.

c. In the third series will be ranged certain small ganglia which are dispersed through the cranium at irregular intervals. These are connected more or less directly with the upper part of the gangliated cords, and more immediately with the fifth pair of cranial nerves. They furnish branches for the most part to the organs of sense; and they are known as the ophthalmic, the spheno-palatine, otic, and submaxillary ganglia.

The ganglia last referred to having been before fully described in

* For an account of the microscopical appearance of the sympathetic nerve, see the General Anatomy of Nerve.

connexion with the fifth pair of cranial nerves, it remains to enter here into the details of the first two divisions of the sympathetic system.

A. THE GANGLIATED CORDS.

1. THE CERVICAL PART.

In the neck each gangliated cord is deeply placed beneath the sheath of the great cervical blood-vessels, and is in contact with the muscles which immediately cover the fore part of the vertebral column. It comprises but three ganglia, which are distinguished by their relative position, being placed respectively at the upper and lower end and the middle of the neck. The ganglia require to be separately described.

THE UPPER CERVICAL GANGLION.

This is the largest of the ganglia of the gangliated cord. It is usually fusiform in shape: but there is a good deal of variety in this respect in different cases, the ganglion being occasionally broader than usual (in various degrees), and from time to time constricted at intervals.* It has the reddish-gray colour characteristic of the ganglia of the sympathetic system; and it is placed on the larger rectus muscle, opposite the second and third cervical vertebræ, and beneath the internal carotid artery.

Connexion with spinal nerves.—At its outer side the superior cervical ganglion is connected with the first four spinal nerves, and the connecting cords have the arrangement before pointed out in the general description (page 339).

Connexion with cranial nerves.—Small branches connect the ganglion or its cranial cord, with the second ganglion of the pneumogastric, and with the ninth cranial nerve near the base of the skull. And in this place may likewise be noticed another branch, which is directed upwards from the cord issuing from the upper part of the ganglion, and divides at the base of the skull into two filaments. One of these ends in the second (petrosal) ganglion of the glosso-pharyngeal nerve; while the other, entering the jugular foramen, joins the ganglion of the root of the pneumogastric.

BRANCHES OF THE GANGLION.

Pharyngeal Nerves and Pharyngeal Plexus.

These nerves arise from the upper part of the ganglion, and are directed obliquely inwards to the side of the pharynx. Opposite the middle constrictor muscle they unite with branches of the pneumogastric and glosso-pharyngeal nerves; and by their union with those nerves the *pharyngeal plexus* is constructed. Branches emanating from the plexus are distributed to the muscles and mucous membrane of the pharynx.

* The occurrence of constrictions has given rise to the opinion that the ganglion may result from the coalescence of several ganglia; and in this way it has been sought to account for its greater size, and for the diminished number of the cervical ganglia.

Upper Cardiac Nerve.

A few preliminary remarks on the cardiac nerves are here necessary. The cervical ganglia of the sympathetic furnish each a cardiac branch, named, like the ganglion from which it arises, upper, middle, and lower; but the branches are not altogether disposed in the same way on the opposite sides of the body, and we shall therefore have to notice the two sides separately.

The cardiac nerves are continued singly, or in connexion, to the large prevertebral plexus (cardiac plexus) of the thorax. In this, as in other parts of the sympathetic system, considerable variety occurs as to the disposition of the branches in different cases; and where one branch happens to be of smaller size than common, another will be found to possess an increased size, as if to compensate for the defect. But the arrangement of the branches at their termination in the organs to which they are distributed appears to be always the same.

The *upper cardiac nerve* (r. cardiacus superficialis) of the *right side*, is constructed from two or more branches of the ganglion, with, in some instances, an offset from the cord connecting the first two ganglia. In its course in the neck the nerve lies behind the carotid sheath, in contact with the longus colli muscle; and it is placed over the lower thyroid artery and the recurrent laryngeal nerve. Entering the thorax, it passes, in some cases before, in others behind the subclavian artery, and is directed along the innominate artery to the back part of the arch of the aorta, where it ends in the deep cardiac plexus, a few small filaments continuing also to the front of the great vessel. Some branches are distributed to the thyroid body; they accompany the inferior thyroid artery.

In its course downwards the cardiac nerve is repeatedly connected with other branches of the sympathetic, and with the pneumogastric nerve. Thus, about the middle of the neck it is joined by some filaments from the external laryngeal nerve; and, rather lower down, by one or more filaments from the trunk of the pneumogastric nerve; lastly, on entering the chest, it joins with the recurrent laryngeal. Instead of passing to the thorax in the manner above described, the nerve may be found to join the cardiac branch furnished from one of the other cervical ganglia.*

The superficial cardiac nerve of the *left side* has, while in the neck, the same course and connexions as that of the right side. But within the chest it follows the left carotid artery to the arch of the aorta, and ends in some instances in the superficial cardiac plexus, while in others it joins the deep plexus; and accordingly it passes either in front of the arch of the aorta or behind it.

Vascular Branches.

The nerves which ramify on the arteries (nervi molles) spring from the front of the ganglion, and reach the trunk of the carotid artery, which they entwine. An offset is continued on each branch of the

* Scarpa describes this as the common disposition of the superficial cardiac nerve, but M. Cruveilhier (Anat. Descript., t. iv.) states that he has not in any case found the cardiac nerves exactly to correspond with the figures of the "Tabulæ Neurologicæ."

external carotid, and forms a slender plexus upon it. These nerves or plexuses have the same designation as the arteries they surround. From the plexus on the facial artery is derived the filament which joins the submaxillary ganglion; and, from that on the middle meningeal artery, offsets have been described as extending to the otic ganglion, as well as to the gangliform enlargement of the facial nerve (ante, page 279 and fig. 357.) Lastly, a communication is established between the plexus on the carotid artery and the digastric branch of the facial nerve.

Small ganglia are occasionally found on some of the foregoing vascular plexuses, close to the origin of the vessels with which they are associated. Those which have been described are an inter-carotid one (placed in the angle of the bifurcation of the common carotid artery), and lingual, temporal, and pharyngeal ganglia.

The foregoing branches will be found to correspond in a great measure with the branches of other ganglia; but we now proceed to examine an offset which is peculiar to the first cervical ganglion.

Ascending or Cranial Branch.

The ascending offset of the first cervical ganglion is soft in texture and of a reddish tint, seeming to be in some degree a prolongation of the ganglion itself. In its course to the skull, it is concealed by the internal carotid artery, with which it enters the carotid canal in the temporal bone; and it is then divided into two parts, which are placed one on the outer side, the other on the inner side of the vessel.

The *external part*, or division, distributes filaments to the internal carotid artery, and, after communicating by means of other filaments with the internal division of the cord, forms the *carotid plexus*.

The *inner division*, rather the smaller of the two, also supplies filaments to the carotid artery, and goes to form what is named the *cavernous plexus*. The several parts of these divisions of the cranial cord are prolonged on the trunk of the internal carotid, and extend to the cerebral and ophthalmic arteries, around which they form secondary plexuses.* One plexus enters the eyeball with the central artery of the retina.

Carotid Plexus.

The carotid plexus, situate, as before mentioned, on the outer side of the internal carotid artery at its second bend (reckoning from below), or between the second or third bends, joins the fifth and sixth nerves, and gives many filaments to the vessel on which it lies.†

Branches.—1. The connexion with the *sixth nerve* is established by means of one or two filaments of considerable size, which are applied to that nerve where it lies by the side of the internal carotid artery.

2. The filaments connected with the *Gasserian ganglion* of the fifth nerve proceed in one case from the carotid plexus, in another from the cavernous.

* It was said by Ribes (Mem. de la Société Méd. d'Emulation, tom. viii. p. 606,) that the cranial prolongations of the sympathetic nerve from both sides were joined one with the other on the anterior communicating artery,—a small ganglion or a plexus being formed at the point of juncture. This connexion has not been satisfactorily made out by other observers.

† Valentin describes nerves furnished to the dura mater from this plexus.

3. The filament which constitutes the deep branch or part of *the vidian nerve* is directed forwards to the pterygoid canal, through the cartilaginous substance closing the foramen lacerum anterius in the base of the skull. In that canal it becomes associated with the deep branch of the vidian, and is continued forward to the spheno-palatine ganglion. (See ante, page 272.)

Cavernous Plexus.

The cavernous plexus, named from its position in the sinus of the same name, is placed below and rather to the inner side of the highest turn of the internal carotid artery. Besides giving branches on the artery, it communicates with the third, the fourth, and fifth cranial nerves which enter the orbit.*

Branches.—1. The filament which joins the *third nerve* comes into connexion with it close to the point of division of that nerve.

2. The branch to the *fourth nerve*, which may be derived from either the cavernous or carotid plexus, joins the nerve where it lies in the wall of the cavernous sinus.

3. The filaments connected with the *ophthalmic division* of the *fifth* nerve are supplied to its inner surface. One of them is continued forward to the lenticular ganglion, either in connexion with, or distinct from the nasal nerve (ante, 267).

MIDDLE CERVICAL GANGLION.

The middle ganglion (ganglion thyroideum), which is much the smallest of the cervical ganglia, is placed on or near the inferior thyroid artery. It is usually connected in the ordinary way with the fifth and the sixth spinal nerves, but the communication with those nerves is not constant.

BRANCHES DERIVED FROM THE GANGLION.

Thyroid branches.—From the inner side of the ganglion some nerves proceed along the inferior thyroid artery to the thyroid body, where they join the recurrent laryngeal and the external laryngeal nerves. Whilst on the artery, these branches communicate with the upper cardiac nerve.

Middle Cardiac Nerve.

The middle cardiac nerve (nervus cardiacus profundus v. magnus) is prolonged to the chest beneath the sheath of the common carotid artery, and in front of the subclavian artery, or, it may be, behind this vessel. In the chest it lies on the trachea, where it is joined by filaments of the recurrent laryngeal nerve, and it ends in the right side of the deep cardiac plexus. While in the neck, the nerve communicates with the upper cardiac nerve and the recurrent branch of the pneumogastric.—When the middle cervical ganglion is small, the middle cardiac nerve may be found to be an offset of the inter-ganglionic cord.

The foregoing account of the nerve has reference to the right side of the body: on the *left side*, the middle cardiac nerve enters the chest between the left carotid and subclavian arteries, and joins the left side of the deep cardiac plexus.

* A second communication between the sympathetic and the sixth nerve, taking place below the bend of the carotid, has been described by some anatomists.

LOWER CERVICAL GANGLION.

The lower or third cervical ganglion is irregular in shape, usually somewhat round or semilunar, and is frequently united in part to the first thoracic ganglion. Placed in a hollow between the transverse process of the last cervical vertebra and the neck of the first rib, it is concealed by the vertebral artery.

Connexion with spinal nerves.—This ganglion is connected directly by short communicating cords, in the manner of other ganglia, with the last two cervical nerves. Moreover, branches which pass from the ganglion along the vertebral artery, supplying twigs to this vessel, are also connected with other cervical nerves, and thus additional communications are established between the two systems.

BRANCHES OF THE LOWER CERVICAL GANGLION.

Lower Cardiac Nerve.

The lower cardiac nerve, issuing from the third cervical ganglion or from the first thoracic, and inclining inwards behind the subclavian artery, terminates, like the other cardiac nerves, in the cardiac plexus behind the arch of the aorta. It communicates with the middle cardiac and recurrent laryngeal nerves behind the subclavian artery. On the *left side*, the lower cardiac often becomes blended with the middle cardiac nerve, and the cord resulting from their union terminates in the deep cardiac plexus.

Branches on the vertebral artery; vertebral plexus.—From the lowest cervical and the first dorsal ganglia a few slender branches ascend along the vertebral artery in its osseous canal, forming a plexus round the vessel by their intercommunications, and supplying it with offsets.* This plexus is connected with the cervical spinal nerves as far upwards as the fourth.

A couple of branches pass from the lower cervical ganglion to the first dorsal ganglion in front of the subclavian artery, forming loops round the vessel (ansæ Vieussenii), and supplying it with small offsets.

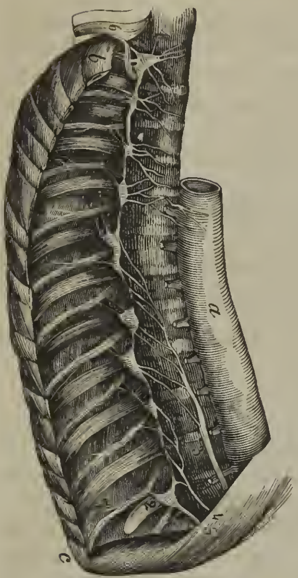
2. THORACIC PART OF THE GANGLIATED CORD.

In the thorax the knotted cord is placed on each side of the spinal column, over the line of the heads of the ribs; and it is uninterruptedly continuous with the same part in the neck and in the abdomen. It is covered by the pleura.

Opposite the head of each rib the cord presents for the most part a grayish enlargement or ganglion, so that there are commonly twelve of these; but, from the occasional coalescence of two masses, the number is uncertain. The first ganglion is much larger than the rest, and is of an elongated form. It is often blended with the lower cervical ganglion. The rest are small, and are not inaptly described as hordeiform.

* Little gangliform enlargements have been described as existing on the plexus, but they do not possess the vesicles which belong to true ganglia (Valentin). The existence of the enlargements in question is doubted by M. Cruveilhier.

Fig. 374.



A representation of the ganglia of the sympathetic in the chest; (the ganglia are represented larger than natural.) The wood-cut is taken from part of a plate in Mr. Swan's work. *a.* Aorta. *b.* First rib. *c.* Eleventh rib. 1. First thoracic ganglion. 2. Last thoracic ganglion. 3. Large splanchnic nerve. 4. Small splanchnic nerve. 5. Smallest splanchnic nerve. 6. Part of the brachial plexus.

Connexion with the spinal nerves.—The branches of connexion between the spinal nerves and the ganglia of the sympathetic, fig. 374, are usually two in number for each ganglion.

BRANCHES OF THE GANGLIA.

The branches furnished by the *first six ganglia*, fig. 374, are much smaller than those of the lower six, and are distributed in a great measure to the thoracic aorta, the vertebræ, and ligaments. One or two branches enter the posterior pulmonary plexus.*

The branches furnished by the *lower six ganglia* unite into cords, which pass from the thorax to the abdomen, and join plexuses in the latter cavity. The cords referred to are three in number on each side, are named "splanchnic," and are distinguished as the great, the small, and the smallest splanchnic nerve.† They occur in the thorax in the order in which they are here mentioned, the largest being at the same time highest, and the smallest lower than the rest.

The Great Splanchnic Nerve.

This nerve or cord, fig. 374,[3] appears at first sight to be formed by roots supplied by the thoracic ganglia from the sixth or seventh to the tenth inclusive; but, by examination after immersion in acetic or diluted nitric acid, small filaments may be traced upwards as far as the third ganglion, or even, according to Mr. Beck, as far as the first.‡

Gradually augmented by the successive addition of the several roots, the cord descends obliquely inwards over the bodies of the dorsal vertebræ; and, after perforating the crus of the diaphragm, (the point at which it passes through the muscle varying in different cases,)

* Mr. Swan represents branches of the second, third, and fourth ganglia as united in a *plexus* (which he names thoracic) on the bodies of the vertebræ. Offsets from the plexus are mentioned by this anatomist as entering the pulmonary and cardiac plexuses, while some are continued beneath the œsophagus to the corresponding plexus on the opposite side.

† Wrisberg noticed a fourth splanchnic nerve, which he found but eight times, though he sought it in many bodies. He proposed to call it the highest splanchnic nerve (nervus splanchnicus supremus). It is described as formed by offsets from the cardiac nerves, and from the lower cervical, as well as some of the upper thoracic ganglia. Consult the "Observ. Anatom. de Nerv. Viscerum particula prima," p. 25, sect. iij. "De nervo sympathico maximo."

‡ See a paper entitled "On the Nerves of the Uterus, by J. S. Beck, Esq.," in the Philosophical Transactions, Part 2, for 1846.

terminates in the semilunar ganglion, frequently also sending some filaments to the renal plexus and the suprarenal body.

The splanchnic nerve is remarkable from its white colour and firmness, which are owing to the preponderance of the spinal nerve-fibre in its composition.

In the chest the great splanchnic nerve is not unfrequently divided into parts, and forms a little plexus with the small splanchnic nerve. Occasionally, too, a small ganglion (ganglion splanchnicum) is formed on it over the last dorsal vertebra, or the last but one; and when it presents a plexiform arrangement, several small ganglia have been observed on its divisions.

Small Splanchnic Nerve.

The small or second splanchnic nerve, fig. 374,[4], springs from the tenth and eleventh ganglia, and from the cord between those ganglia. It continues with the preceding nerve through the diaphragm, and ends in the cœliac plexus. In the chest this nerve often communicates with the large splanchnic nerve; and in some instances it furnishes filaments to the renal plexus, especially if the lowest splanchnic nerve is very small or wanting.

Smallest, or Third Splanchnic Nerve.

This nerve (nerv. renalis posterior—Walter), fig. 374,[5], arises from the last thoracic ganglion, and communicates sometimes with the nerve last described. After piercing the diaphragm, it ends in the renal plexus, and in the lowest part of the cœliac plexus.

3. LUMBAR PART OF THE GANGLIATED CORD.

In the lumbar region the two gangliated cords, continuing from the thoracic series of ganglia behind the diaphragm, approach one to the other more nearly than in the thorax. They are placed before the bodies of the vertebræ, each lying along the inner margin of the psoas muscle; and that of the right side is partly covered by the vena cava.

The ganglia are small, and hordeiform in shape. They are commonly four in number, but occasionally their number is diminished, and then their size is proportionably enlarged.

Connexion with spinal nerves.—In consequence of the greater distance at which the lumbar ganglia are separated from the intervertebral foramina of the spine, the cords connecting them with the spinal lumbar nerves are longer than in other parts of the sympathetic system. There are generally two connecting cords for each ganglion, but the number is not so uniform as it is in the chest; nor are those belonging to any one ganglion connected with the same spinal nerve in all cases.

The connecting cords accompany the lumbar arteries, and, as they cross the bodies of the vertebræ, are covered by the fibrous bands from which the larger psoas muscle partly takes its origin.

Branches of the Lumbar Ganglia.

The branches of these ganglia are uncertain in their number. Some join a plexus on the aorta; others descending go to form the hypo-

gastric plexus. Several filaments are distributed to the vertebræ, and to the ligaments connecting those bones.

4. SACRAL PART OF THE GANGLIATED CORD.

Over the sacrum the gangliated cord of the sympathetic nerve is much diminished in size, and gives but few branches to the viscera. Its position on the front of the sacrum is along the inner side of the anterior sacral foramina; and, like the two series of those foramina, the two cords approach one another in their progress downwards. The upper end of each is connected with the last lumbar ganglion, sometimes by a double inter-ganglionic cord; at the opposite end, the lowest sacral ganglion is connected with that of the other side by means of a single median ganglion. This ganglion (*ganglion impar*) is placed on the fore part of the coccyx. The sacral ganglia are usually five in number; but the want of constancy both in size and number is more marked in these than in the thoracic or lumbar ganglia.

Connexion with spinal nerves.—From the proximity of the sacral ganglia to the spinal nerves at their emergence from the bone, the communicating branches are very short: they are two in number for each ganglion, and are in some cases connected with two different sacral nerves. The coccygeal nerve communicates with the last sacral or the coccygeal ganglion.

Branches of the Sacral Ganglia.

The branches are much smaller in size than those from the ganglia in other parts of the cord. They are for the most part expended on the front of the sacrum, and they join the corresponding branches from the opposite side. Some filaments from one or two of the first ganglia enter the hypogastric plexus, while others go to form a plexus on the middle sacral artery. From the lower end of the sympathetic (i. e., the loop connecting the two cords, and on which the coccygeal ganglion is formed), filaments are given to the coccyx and the ligaments about it.

B. PREVERTEBRAL PART OF THE SYMPATHETIC NERVE.

This portion of the sympathetic system, it has been already stated, consists of certain unsymmetrical plexuses placed before the spine, and serving as centres from which nerves are furnished to the viscera. Those recognised are the cardiac, solar, and hypogastric plexuses. They are composed of assemblages of nerves, or nerves and ganglia. Each receives nerves from the gangliated cord of both sides; and these nerves, as will presently appear in the special description of the plexuses, take origin from the ganglia at a distance above the plexus.

From the plexuses are furnished branches or secondary plexuses for the supply of the viscera. These offsets accompany the arteries in their course to the viscera for which they are respectively destined.

1. CARDIAC PLEXUS.

The prevertebral plexus of the thorax is thus named. To it several

branches (cardiac), given from the cervical ganglia of the sympathetic, and from the vagus nerve, converge as to a common centre; and from it proceed the nerves which supply the heart, as well as some offsets which assist in supplying the lungs.

The large cardiac plexus of nerves lies above the base of the heart upon the two great arteries which issue from it (aorta, and pulmonary artery). In the general network formed by these nerves there are reckoned two subdivisions, which are partially separated one from the other, and are distinguished as the superficial, and the deep or great cardiac plexus. The branches pass from these to the heart, in two bundles, which accompany the nutritious arteries of the organ, and from this circumstance are called coronary plexuses.

Superficial Cardiac Plexus.

The superficial cardiac plexus lies in the concavity of the arch of the aorta, in front of the right branch of the pulmonary artery. In it terminates the superficial or first cardiac nerve of the left side, either wholly or in part, with the lower cardiac branch of the left pneumogastric nerve (in some cases, also, that of the right side); and it is joined by a prolongation forward from the deep cardiac plexus. A small ganglion (*ganglion of Wrisberg*) is frequently found at the point of union of the nerves. The plexus ends in the anterior coronary plexus, and it furnishes laterally filaments along the pulmonary artery to the anterior pulmonary plexus of the left side.

The *anterior coronary plexus*, a prolongation in greatest part from the superficial cardiac plexus above described, is at first continued forward between the aorta and the pulmonary artery, and is thence conducted by the right or anterior coronary artery to the heart. Where the anterior coronary artery appears between the large vessels, the coronary plexus receives an accession from the deep cardiac plexus.

Deep Cardiac Plexus.

The deep cardiac plexus (plexus magnus profundus—Scarpa), is much larger than the superficial one, and is placed behind the arch of the aorta, between it and the end of the trachea, and above the division of the pulmonary artery.

This plexus receives all the cardiac branches of the cervical ganglia of the sympathetic nerve, except the first one (superficial cardiac nerve) of the left side. It likewise receives the cardiac nerves furnished by the vagus and by the recurrent laryngeal branch of that nerve, with the exception of the lower cardiac nerve of the left side.

The nerves issuing from the great cardiac plexus end in greatest part in the posterior coronary plexus. But some join the anterior coronary plexus; and a few filaments are added to the pulmonary plexuses.

There is some difference as to the course pursued by the nerves issuing from the plexus on the right and left side. The branches descending from the *right side* of the plexus pass, some in front of the right pulmonary artery, others behind the vessel. The former, which is much the more numerous set, after sending

some filaments to the anterior pulmonary plexus, are directed along the trunk of the pulmonary artery, and become part of the anterior coronary plexus; while the nerves stated to be behind the right pulmonary artery are distributed to the right auricle of the heart, and a few filaments are continued into the posterior coronary plexus.

On the *left side*, a few branches pass forward by the ductus arteriosus to join the superficial cardiac plexus; but the great body of the nerves of this side end in the posterior coronary plexus, after giving branches to the left auricle of the heart, and to the anterior pulmonary plexus.

The *posterior coronary plexus* is derived chiefly from the left side of the deep cardiac plexus, but is joined by nerves from the right portion of that plexus. It surrounds the branches of the coronary artery at the back of the heart, and supplies mostly the muscular substance of the ventricles.

The nerves constituting the coronary plexuses accompany, as already stated, the branches of the arteries, and, after subdividing minutely, enter the muscular substance of the heart. Nervous filaments are said to ramify under the lining membrane of the heart, but they are not as easily distinguished in man as in some animals, the sheep for example (Valentin). Ganglia of small size have been found by Remak * on the branches of the cardiac nerves in several mammifers, both on the surface of the heart and in the muscular substance, where they were observed to be very numerous; but Valentin failed to detect such ganglia in the human heart.

2. EPIGASTRIC OR SOLAR PLEXUS.

The epigastric plexus, which is the largest of the prevertebral plexuses, is placed at the upper part of the abdomen, behind the stomach, and in front of the aorta and the pillars of the diaphragm. Surrounding the origin of the cœliac axis and the upper mesenteric artery, it occupies the interval between the suprarenal bodies, and extends downwards as far as the pancreas. The plexus consists of nervous cords, and several ganglia of various size connected together by nervous cords. The large splanchnic nerves of both sides, and some branches from the pneumogastric, terminate in it. The offsets or branches sent from it are very numerous, and they accompany the arteries to the principal viscera of the abdomen, constituting so many secondary plexuses on the vessels.

Ganglia.—The solar plexus contains, as already mentioned, several ganglia; and by the presence of these bodies, and their size, it is distinguished from the other prevertebral plexuses. Two of the ganglia (one for each side), which differ from the rest by their greater size, require separate notice. Named *semilunar*, though they have often little of the form the name implies, they occupy the upper and outer part of the plexus on each side, and are placed close to the suprarenal bodies, by the side of the cœliac and the superior mesenteric arteries. At the upper end, which is expanded, each ganglion receives the great splanchnic nerve, and from it, branches radiate in different directions.

Offsets from the plexus.—These have the same plexiform arrangement as the large plexus from which they are derived. Each secondary plexus, as it accompanies a branch of the aorta, surrounds the vessel with a kind of membranous sheath, and is named from the

* Müller's Archiv, 1844.

vessel by which it is supported. Accordingly, diaphragmatic, cœliac, renal, mesenteric, and other plexuses are recognised.

Diaphragmatic Plexuses.

The nerves (inferior diaphragmatic) composing each of these plexuses are derived from the upper part of the semilunar ganglion, and are larger on the right than on the left side. Accompanying the arteries along the lower surface of the diaphragm, the nerves sink into the substance of the muscle. They furnish some filaments to the suprarenal body, and join with the spinal phrenic nerves.

At the right side, on the under surface of the diaphragm, and near the suprarenal body, there is a small ganglion (*gang. diaphragmaticum*), which marks the junction between the phrenic nerves of the spinal and the sympathetic systems. From this small ganglion filaments are distributed to the vena cava, the suprarenal body, and the hepatic plexus. On the left side the ganglion is wanting, but some filaments are prolonged to the hepatic plexus.

Suprarenal Plexus.

The suprarenal nerves issue from the outer part of the semilunar ganglion and from the solar plexus, a few filaments being added from the diaphragmatic nerve. They are short, but numerous in comparison with the size of the body which they supply; and they enter the upper and inner parts of the suprarenal capsule. These nerves are continuous below with the renal plexus. The plexus is joined by branches from one of the splanchnic nerves, and presents a ganglion (*gangl. splanchnico-suprarenale*) where it is connected with those branches. The plexus and ganglion are smaller on the left than on the right side.

Renal Plexus.

The nerves forming the renal plexus, which are about fifteen or twenty in number, emanate for the most part, like the preceding nerves, from the outer part of the semilunar ganglion; but some are added from the solar plexus and the aortic plexus. Moreover, filaments of the smallest splanchnic nerve, and occasionally from the other splanchnic nerves, terminate in the renal plexus. As they follow onwards the renal artery, ganglia of different sizes are formed on these nerves. Lastly, dividing with the divisions of the vessel, the nerves follow the vessels into the substance of the kidney. On the right side some filaments are furnished to the vena cava, behind which the plexus passes with the renal artery, and others go to form the spermatic plexus.

Spermatic Plexus.

This small plexus commences in the renal plexus, but receives in its progress with the spermatic artery an accession from the aortic plexus. Continuing downwards to the testis, the spermatic nerves are connected with others, which accompany the vas deferens and its artery from the pelvis.

In the female, the plexus, like the artery, is distributed to the ovary and the uterus.

Cœliac Plexus, and its subdivisions.

The cœliac plexus is of large size, and is derived from the fore part of the great epigastric plexus. It surrounds the cœliac axis in a kind of membranous sheath, and subdivides, as the artery, into coronary, hepatic, and splenic plexuses. The plexus receives offsets from one or more of the splanchnic nerves, and on the left side a branch from the pneumogastric nerve is continued into it (Swan).

a. The *coronary plexus* is placed with its artery along the small curvature of the stomach, and unites with the nerves which accompany the pyloric artery, as well as with branches of the pneumogastric nerves. The nerves of this plexus enter the coats of the stomach, after lying a short distance beneath the peritoneum.

b. The *hepatic plexus*, the largest of the three divisions of the cœliac plexus, ascends with the hepatic vessels and the bile-duct, and, entering the substance of the liver, ramifies on the branches of the vena portæ and the hepatic artery. Offsets from the left pneumogastric and from the diaphragmatic nerves join the hepatic nerves at the left side of the hepatic vessels. From this plexus are furnished filaments to the right suprarenal plexus, as well as other secondary plexuses which follow branches of the hepatic artery. Thus there is with the pyloric artery a *pyloric plexus*, which gives branches on the small curvature of the stomach, and is connected with the pneumogastric nerves, as well as with the plexus on the coronary artery. Again, a *gastro-epiploïc* and a *gastro-duodenal plexus* are furnished from the hepatic plexus. The former surrounds the right gastro-epiploïc artery, and communicates with the nerves from the splenic plexus, which lie on the left gastro-epiploïc vessel; while the gastro-duodenal plexus supplies the duodenum and the pancreas, and joins the mesenteric plexus. The plexuses just noticed supply filaments to the stomach, chiefly at its pyloric end. Near the liver the *cystic plexus* is derived from the same source as the nerves last described, and is conveyed to the gall-bladder by the cystic artery.

c. The *splenic plexus* is continued on the splenic artery and its divisions into the substance of the spleen. This plexus is reinforced at its beginning by branches from the left semilunar ganglion, and by a filament from the right vagus nerve. It furnishes the *left gastro-epiploïc* and *pancreatic* plexuses, which course along the branches of the splenic artery bearing the same appellation, and, like the vessels, are distributed to the stomach and pancreas.

Superior Mesenteric Plexus.

The plexus accompanying the superior mesenteric artery, whiter in colour and firmer than either of the preceding offsets of the solar plexus, envelopes the artery in a membraniform tube, and receives a prolongation from the junction of the right pneumogastric nerve with the cœliac plexus. About the root of the artery, ganglionic masses (gangl. meseraica) occur in connexion with the nerves of this plexus.

The offsets of the plexus are in name and number the same as the vessels; and, in the same manner as the vessels, they supply the greater part of the small intestines, viz., the jejunum and ileum, as well as the ascending and the transverse colon. The pancreas also receives nerves from the superior mesenteric plexus. The nerves are distributed as follows :—

Closely encircling the superior mesenteric artery, the plexus enters with that vessel between the layers of the mesentery, and furnishes secondary plexuses around the branches of the artery: viz., *intestinal* nerves to the small intestine, and plexuses for the supply of the large intestine, named severally *ileo-colic*, *right colic*, and *middle colic*. In their progress to the intestine some nerves quit the arteries which first supported them, and are directed forwards in the intervals between the vessels. As they proceed, they divide, and unite with lateral branches, like the arteries, but without the same regularity; and they enter the intestine where the mesentery is connected with it. The highest of the foregoing nerves, those on the jejunum, communicate with the gastro-duodenal plexus; and those distributed to the transverse colon (middle colic nerves) join with the left colic nerves furnished from the inferior mesenteric plexus.

The Aortic Plexus.

The aortic or inter-mesenteric plexus is placed along the abdominal aorta, and occupies the interval between the origin of the superior and inferior mesenteric arteries. This plexus may be considered a prolongation of the solar plexus, which supplies nerves to accompany some of the lower branches of the aorta. Above, it consists, for the most part, of two lateral portions, (connected with the semilunar ganglia and renal plexuses,) which are extended on the sides of the aorta, but with communicating branches over that vessel. It is joined, moreover, by branches of some of the lumbar ganglia.

The aortic plexus furnishes the inferior mesenteric plexus and part of the spermatic, gives some filaments to the lower vena cava, and ends in the hypogastric plexus.

Inferior Mesenteric Plexus.

The inferior mesenteric plexus is derived principally from the left lateral part of the aortic plexus, and closely surrounds with a network the inferior mesenteric artery. It distributes nerves to the left or descending part, and the sigmoid flexure of the colon, and assists in supplying the rectum. The nerves of this plexus, like those of the superior mesenteric plexus, are firm in texture, and whitish in colour.

As it proceeds along the artery, the inferior mesenteric plexus divides into the following secondary plexuses, viz., *left colic*, *sigmoid*, and *superior hæmorrhoidal*, which surround respectively the branches of the artery. In their progress to the intestine, the nerves of these plexuses subdivide, and join, like the branches of the superior mesenteric nerves: the highest branches (those on the left colic artery) are connected with the last branches (middle colic) of the superior mesen-

teric plexus, while others in the pelvis unite with offsets from the inferior hypogastric plexus of the left side.

3. HYPOGASTRIC PLEXUS.

The hypogastric plexus (plexus hypogastricus superior, seu uterinus communis—Tiedemann ; plex. hypogastr. medius seu impar—Müller; inferior aortic plexus), the prevertebral assemblage of nerves destined for the supply of the viscera of the pelvis, lies invested in dense cellular membrane, in the interval between the two common iliac arteries. The nerves from which it is formed, about twelve in number on each side, descend from the aortic plexus, receiving filaments from the lumbar ganglia, and, after crossing the common iliac artery, form an interlacement with as many nerves from the opposite side. The plexus contains no ganglia. At the lower end it divides into two parts, which are directed forward, one to each side of the pelvic viscera.

Inferior Hypogastric Plexuses.

Inferior hypogastric plexus (plexus gangliosus inferior; hypogastricus lateralis inferior—Tiedemann; plexus hypogastricus inferior—Müller; pelvic plexus—Beck). Each of the two prolongations of the hypogastric plexus is continued forward by the side of the rectum, its branches entering into repeated communications as they descend, and forming at the points of connexion small knots, which contain a little ganglionic matter. After descending some way, they become united with branches of the spinal nerves, as well as with a few offsets of the sacral ganglia, and the union of all constitutes the inferior hypogastric plexus. The spinal branches, which enter into the plexus, are furnished from the third and fourth sacral nerves (in greatest number by the former of these); a couple of filaments being likewise added from the second sacral nerve. Small ganglia are formed at the place of union of the nerves, as well as elsewhere in the plexus (plexus gangliosus—Tiedemann).

From the plexus so constituted numerous nerves are distributed to the pelvic viscera. They correspond with the branches of the internal iliac artery, and of course vary with the sex; thus, besides hæmorrhoidal and vesical nerves, which are common to both sexes, there are nerves special to each, namely, those destined, in the male, for the prostate, vesicula seminalis, and vas deferens; in the female, for the vagina, uterus, ovary, and Fallopian tube.

The nerves distributed to the urinary bladder and the vagina contain a larger proportion of spinal nerves than those furnished to the other pelvic viscera.—The offsets of the inferior hypogastric plexus will now be noticed separately.

Inferior Hæmorrhoidal Nerves.

These slender nerves pass away from the back part of the inferior hypogastric plexus. They join with the nerves (superior hæmorrhoidal) which descend from the abdomen with the inferior mesenteric artery, and penetrate the coats of the rectum.

Vesical Plexus.

The nerves of the urinary bladder are very numerous. They are directed from the anterior part of the inferior hypogastric plexus to the side and lower part of the bladder. At first, these nerves accompany the vesical blood-vessels, but afterwards they leave the vessels, and subdivide into minute fibrils, before perforating the muscular coat of the organ. From the vesical plexus, nerves, or what may be considered secondary plexuses, are given in the male to the vas deferens and the vesicula seminalis.

a. The *nerves of the vas deferens* ramify around that tube, and communicate in the spermatic cord with the nerves of the spermatic plexus. *b.* Those furnished to the *vesicula seminalis* form an interlacement on the vesicula, and some branches penetrate its substance. Other filaments from the prostatic nerves reach the same structure.

Prostatic Plexus.

This plexus is continued from the lower part of the inferior hypogastric plexus. The nerves are of considerable size, and pass onwards between the prostate and the levator ani. Some are furnished to the gland (from which they are named), and to the vesicula seminalis; and the plexus is then continued forward to supply the erectile substance of the penis, where the nerves are named "cavernous."

Cavernous nerves (of the penis).*—These are very slender, and difficult to dissect. Continuing from the prostatic plexus, at the fore part of the prostate gland, they pass onwards beneath the arch of the pubes, and through the muscular structure connected with the membranous part of the urethra, to the dorsum of the penis. At the anterior margin of the levator ani muscle some short filaments from the pudic nerve join the cavernous nerves. After distributing twigs to the prostate at its fore part, these nerves divide into branches for the erectile substance of the penis, as follows:

a. Small cavernous nerves (nervi cavernosi minores—Müller), which perforate the fibrous covering of the corpus cavernosum near the root of the penis, and end in the erectile substance.

b. The *large cavernous nerve* (n. cavernosus major), which extends forward on the dorsum of the penis, and dividing, gives filaments that penetrate the corpus cavernosum, passing with or near the cavernous artery (art. profunda penis). As it continues onwards, this nerve joins with the dorsal branch of the pudic nerve, about the middle of the penis, and is distributed to the corpus cavernosum. Branches from the foregoing nerves reach the corpus spongiosum urethræ.

The remaining nerves are peculiar to the female.

Nerves of the Ovary.

The ovary is supplied chiefly from the plexus prolonged on the ovarian artery from the abdomen; but it receives another offset from the uterine nerves.

* These nerves have been made the subject of a monograph by Professor Müller; it is entitled "Ueber die Organischen Nerven der erectilen männlichen Geschlechts-organe," &c. Berlin, 1836.

Vaginal Plexus.

The nerves furnished to the vagina leave the lower part of the inferior hypogastric plexus—that part with which the spinal nerves are more particularly combined. They are distributed to the vagina without previously entering into a plexiform arrangement; and they end in the erectile tissue, on its lower and anterior part.

Nerves of the Uterus.

These nerves are given from the upper part of the inferior hypogastric plexus—more immediately from the lateral fasciculus prolonged to this plexus from the hypogastric plexus, above the point of connexion with the sacral nerves. Separating from the plexus opposite the neck of the uterus, they are directed upwards with the blood-vessels along the side of this organ, between the layers of its broad ligament. The larger part of the nerves soon leave the vessels, and after dividing repeatedly, (but without communicating one with the other, and without forming any gangliform enlargements,) sink into the substance of the uterus, penetrating, for the most part, its neck and the lower part of its body. One branch, continuing directly from the common hypogastric plexus, reaches the body of the uterus above the rest; and a nerve from the same source ascends to the Fallopian tube. Some very slender filaments are differently disposed from the preceding nerves: these form a plexus round the arteries, and terminate on or with those vessels. On the last-mentioned plexiform vascular branches minute ganglia are formed at intervals. Lastly, the fundus of the uterus often receives a branch from the ovarian nerve.* (See Mr. Beck's paper, especially the plate marked 12.)

The *nerves of the gravid uterus.*—The recent dissections of Mr. Beck (if, as they seem to be, accurate) prove that the nerves do not alter in their thickness during pregnancy, at least, that no alteration occurs before they enter the tissue of the uterus; while that organ itself, and the vessels which supply it, undergo a remarkable augmentation in size.

It is doubtless owing to the great difficulty of dissecting the uterine nerves, mixed up as they are with arteries, veins, and lymphatics, together with laminated cellular membrane, and, as a result of this difficulty, to the want of adequate dissections, that anatomists have come to opposite conclusions respecting the state of the nerves in the circumstances indicated in the last paragraph; some, as

* From the preceding statement it may be inferred that the uterus does not receive any considerable supply of nerves. It is necessary, however, to mention, that Dr. Robert Lee has described and given representations of a large additional system of uterine nerves not previously noticed by any anatomist, at least not noticed as nervous structures; and the observations of this inquirer, if correct, would prove that the uterus is supplied with nerves in great abundance,—that it is in fact to a considerable extent covered with a stratum of nervous plexuses and ganglia.

The editor has not embodied the statements peculiar to Dr. Lee with the account of the uterine nerves contained in this work, in consequence of having come to the conclusion, from his own examination of the subject, that Dr. Lee has been mistaken with respect to the nature of the structure he has been the first to describe as nerve—namely, the layer of fibres lying immediately under the peritoneum in the form of "a great web," and extending over a large part of the uterus.—For the details of the researches here adverted to, see "The Anatomy of the Nerves of the Uterus," by Robt. Lee, M.D., F.R.S., London, Baillière, 1841; and two papers by the same author in the "Philosophical Transactions" for 1842.

William Hunter, Professor Tiedemann, and Dr. Lee, stating that the nerves are enlarged in the gravid uterus; while others, including John Hunter, maintained the opposite opinion. With respect to the researches of Mr. Beck referred to in the text: the representations of the gravid uterus and of the unimpregnated uterus of a person who had borne children, which are contained in his paper, show the nervous fibrils to be of the same size in both cases; and the author (it is stated in a note, page 222,) has ascertained by another dissection, that no difference in thickness is perceptible between the nerves of the virgin uterus and those just alluded to.

ORGANS OF THE SENSES.

THE EYE.

Besides the several structures which compose the globe of the eye, and constitute it an optical instrument, there are certain external accessory parts which protect that organ, and are intimately connected with the proper performance of its functions. These are known as the "appendages of the eye," (they have been named likewise tutamina oculi); and they include the eyebrows, the eyelids, the organs for secreting the sebaceous matter, and the tears, together with the canals by which the latter fluid is conveyed to the nose. The orbits in which the eyes are lodged have been already described (ante, vol. i. p. 159).

A. APPENDAGES OF THE EYE.

1. THE EYEBROWS.

The eyebrows (supercilia) are arched ridges, surmounting on each side the upper border of the orbit, and forming a boundary between the forehead and the upper eyelid. They consist of thick integument, studded with stiff, obliquely set hairs, under which lies some fat, with part of the orbicularis palpebrarum and the corrugator supercilii muscles. By the last-named muscle and the occipito-frontalis the brows are moved in opposite directions, to influence the admission of light to the eye, and in the expression of different passions.

2. THE EYELIDS.

The eyelids (palpebræ) are two thin movable folds placed in front of each eye, and calculated to conceal it, or leave it exposed, as occasion may require. The upper lid is larger and more movable than the lower, and has a muscle (levator palpebræ superioris) exclusively intended for its elevation. Descending below the middle of the eye, the upper lid covers the transparent part of the organ; and the eye is opened, or rather the lids are separated, by the elevation of the upper one under the influence of the muscle referred to. The eyelids are joined at the outer and inner angles (*canthi*) of the eye; the interval between the canthi (*fissura palpebrarum*) varies in length in different persons, and, according to its extent, (the size of the globe being nearly the same,) gives the appearance of a larger or a smaller eye. At the outer angle, which is more acute than the inner, the lids are in close contact with the eyeball; but, at the inner canthus, the caruncula lachrymalis intervenes. The free margins of the lids are straight, so that they leave between them, when approximated, merely a transverse chink. The greater part of the edge is flattened, but towards the inner canthus it is rounded off for a short space; and, where the

two differently formed parts join, there exists on each lid a slight conical elevation (*papilla lachrymalis*), the apex of which is pierced by the aperture (punctum) of the corresponding lachrymal duct.

Structure of the lids.—The skin covering the eyelids is thin and delicate; and at the line of the eyelashes, altered in its character, joins the conjunctival mucous membrane which lines the inner surface of the lids and is reflected over the front of the eyeball. Beneath the skin, and in the fold formed between it and the conjunctiva, the following structures are successively met with, viz.:—a layer of fine cellular tissue, without fat; the fibres of the orbicular muscle; a thin fibrous membrane, attached round the margin of the orbit to the periosteum; the tarsal cartilages, to which also this fibrous membrane is connected; and finally the Meibomian glands. In the upper eyelid there is (in addition to these parts, which are common to both lids,) an expansion from the tendon of the levator palpebræ, already noticed: it lies close against the conjunctiva. The structures now enumerated require separate examination.

The *tarsal cartilages* (tarsi) are two thin plates of fibro-cartilage, placed one in each lid, and serving to give shape and firmness to these parts. The upper cartilage, the larger, is half oval in form, being broader near the centre and narrowing towards the angles of the lids; the lower is thinner, smaller, and more nearly of a uniform breadth throughout. The free or ciliary edge of the cartilages, which is straight, is thicker than any other part. The margin towards the orbit is thin, and connected to the periosteum by means of a layer of fibrous membrane, which is stronger near the outer canthus than elsewhere, and has been there named the *external tarsal ligament.* The thin edge of the upper cartilage likewise receives the tendon of the levator palpebræ muscle. Near the inner canthus the cartilages end in fibrous slips, which are closely attached to the tendo palpebrarum (see vol. i. p. 335).

Meibomian glands (glandulæ Meibomii), fig. 375.—On the ocular surface of each lid are seen from thirty to forty parallel vertical lines of yellow granules, lying immediately under the conjunctival mucous membrane. They are sebaceous follicles, embedded in grooves at the back of the tarsal cartilages, and opening on the free margin of the lids by minute orifices, generally as many in number as the lines of follicles themselves. These glands consist of nearly straight excretory tubes, each of which is closed at the end, and has

Fig. 375.

Meibomian glands seen from the inner or ocular surface of the eyelids, with the lachrymal gland—the right side.—*a.* Palpebral conjunctiva. 1. Lachrymal gland. 2. Openings of lachrymal ducts. 3. Lachrymal puncta. 6. Meibomian glands.

numerous small, sessile, cæcal appendages growing from its sides. The tubes are lined by mucous membrane, on the surface of which is a layer of scaly or pavement epithelium cells.

The *eyelashes* (cilia) are short curved hairs, arranged in two or more rows along the margin of the lids, just at the line of union between the skin and conjunctival mucous membrane. The lashes of the upper lid, more numerous and longer than the lower, have the convexity of their curve directed downwards and forwards; whilst those of the lower lid are arched in the opposite direction. Near the inner canthus these hairs are weaker and more scattered. A few slender hairs grow likewise from the caruncula lachrymalis.

Caruncula lachrymalis, fig. 376. — This is a small red conical body, occupying the inner angle of the eyelids; it consists of a group of follicles, covered by mucous membrane. The membrane on the outer side of the caruncle is formed into a semilunar fold (*plica semilunaris*), the concavity of which looks towards the cornea. The follicles secrete a peculiar fluid for lubricating the mucous surface; and the semilunar fold of the membrane is considered as the rudiment of the third eyelid (membrana nictitans) found in some animals.

3. THE LACHRYMAL APPARATUS.

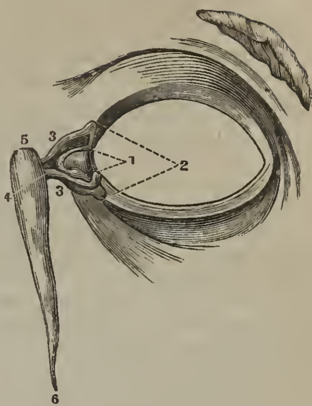
The assemblage of parts which constitute the lachrymal apparatus are the following, viz.:—the gland by which the tears are secreted at the outer side of the orbit; the two canals into which the fluid is received near the inner canthi; and the sac with the duct continued from it, through which the tears pass to the interior of the nose.

The *lachrymal gland*, fig. 375,[1], is an oblong body, about the size of a small almond, placed in the upper and outer part of the orbit, and immediately behind its anterior margin. The upper surface of the gland, convex, is lodged in a depression in the orbital plate of the frontal bone, to the periosteum of which it adheres by fibrous bands; the lower surface is adapted to the convexity of the eyeball, and is in contact with the upper and the outer recti muscles. The fore part of the gland, separated from the body of the organ by a slight depression, and sometimes described as a second lobe, is closely adherent to the back of the upper eyelid, and is covered, on the ocular surface, only by a reflection of the conjunctiva. The lachrymal ducts, usually eight or ten in number, are very small, and emerge from the thinner portion of the gland. After running obliquely under the mucous membrane, and separating at the same time one from the other, they open by separate orifices, fig. 375,[2], a little above the outer canthus.

Lachrymal canals.—On the margin of each lid, near the inner angle, and in front of the fold of membrane called plica semilunaris, is a small elevation (papilla lachrymalis), already described. Each papilla is perforated by a small aperture (*punctum lachrymale*), fig. 375,[3], 376,[1]; and at these apertures commence two small canals (*canaliculi*), fig. 376,[2], which convey the tears from the eye to the lachrymal sac. The upper canal is rather the smaller and longer of the two: it first ascends from the punctum; then makes a sudden bend, and is

directed inwards and downwards to join the lachrymal sac. The lower canal descends from the corresponding punctum; and soon changing its direction, as the upper one, takes a nearly horizontal course inwards. Both canals are dilated where they are bent. In some cases they unite near the end to form a short common trunk: more commonly they open separately, but close together, into the sac.

[Fig. 376.



Anterior view of the Lachrymal Apparatus. At the inner canthus are the puncta, 1, and canaliculi, 2, with the caruncula between them. The lachrymal sac forms the upper third of the vertical tube, 5, 6, and the nasal duct the remainder. These parts are separated within by a fold of the lining membrane.—After Sœmmerring.]

The *lachrymal sac* and *nasal duct* together constitute the passage by which the tears are conveyed from the lachrymal canals to the cavity of the nose. The lachrymal sac, fig. 376,[5], the upper dilated portion of the passage, is situate at the side of the nose, near the inner canthus of the eye, and lies embedded in a deep groove in the ungual and upper maxillary bones. It is of an oval form; the upper end closed and rounded, the lower end gradually narrowing into the nasal duct; on the outer side, and a little in front, it receives the lachrymal canals. The sac is composed of fibrous membrane, adhering closely to the bones above mentioned, and strengthened by fibrous processes sent from the tendo palpebrarum, which crosses a little above its middle. The inner surface is covered by a reddish mucous membrane, which is continuous, through the canaliculi, with the conjunctiva, and through the nasal duct with the mucous membrane of the nose. The sac is covered by the tendo palpebrarum, and by some of the inner fibres of the orbicular muscle of the lids.

The nasal duct (ductus ad nasum), about six or seven lines in length, extends through the upper maxillary bone to the fore part of the lower meatus of the nose, the osseous canal being completed by the ungual and lower turbinate bones. A tube of fibrous membrane, continuous with the lachrymal sac, adheres to the parietes of this canal, and is lined by mucous membrane, which, at the opening into the nose, is often arranged in the form of an imperfect valve. The nasal duct is rather narrower in the middle than at either end; its direction is not quite vertical, but inclines slightly outwards and backwards.

4. THE CONJUNCTIVA.

The conjunctiva is a mucous membrane which lines the ocular surface of the eyelids, and is reflected over the fore part of the sclerotic, and the anterior surface of the cornea. Over each of these several parts it presents peculiar and distinctive characters.

a. The *palpebral portion* of the conjunctiva is opaque and red, is thicker and

more vascular than any other part of the membrane, and has on its free surface numerous fine papillæ, freely supplied with nerves and covered with epithelium. At the margins of the lids the palpebral conjunctiva enters the ducts of the Meibomian glands; through the puncta lachrymalia it passes into the canaliculi, and is continuous with the lining membrane of the lachrymal sac; and it is prolonged into the orifices of the ducts of the lachrymal gland. At the inner canthus it is folded to form the plica semilunaris, and covers the caruncula lachrymalis.

b. The *sclerotic portion* of the conjunctiva, changing its character at the line of reflection from the eyelids, becomes thinner, and loses its papillary structure. It is also transparent and nearly colourless, although generally marked by a few scattered branches of blood-vessels. The vessels of the sclerotic portion are arranged in two layers, which are supplied from different sources, but anastomose freely, particularly round the margin of the cornea. Of these the superficial network is derived from the palpebral and lachrymal arteries; and the deep layer, from the muscular and anterior ciliary branches of the ophthalmic artery.

c. The *corneal conjunctiva* is still thinner than the sclerotic portion of the membrane, and is still more transparent and adherent. Vessels are said to have been recently demonstrated* in this part of the conjunctiva in the healthy eye, their arrangement being as follows:—The vessels form by close anastomoses a circle around the border of the cornea; and, from the angles of union between them, minute offsets pass towards the centre of the cornea, while others arising in the same place insinuate themselves between the cornea and sclerotic, and become connected with the vessels of the choroid.

B. THE GLOBE OF THE EYE.

The globe or ball of the eye is placed in the fore part of the orbital cavity, fixed principally by its connexion with the optic nerve behind, and the muscles with the eyelids in front, but capable of changing its position within certain limits. The recti and obliqui muscles closely surround the greater part of the eyeball; the lids, with the plica semilunaris, and caruncle, are in contact with it in front; and behind it is supported by a quantity of loose fat. The form of the eyeball is irregularly spheroidal; and, when viewed in profile, is found to be composed of segments of two spheres, of which the anterior is the smaller and more prominent: hence the diameter taken from before backwards exceeds the transverse diameter by about a line. The segment of the larger sphere corresponds to the sclerotic coat, and the portion of the smaller sphere to the cornea.

Except when certain muscles are in action, the axes of the eyes are nearly parallel; the optic nerves on the contrary diverge considerably from one another, and consequently each nerve enters the corresponding eye a little to the inner or nasal side of the axis of the globe.

The eyeball is composed of several investing membranes, concentrically arranged, and of certain fluid and solid parts contained within them. The membranes, neither of which forms a complete coat to the eye, are the conjunctiva, sclerotica, cornea, choroid, iris, retina, membrane of the aqueous humour, capsule of the lens, and hyaloid membrane. The parts enclosed are the aqueous and vitreous humours, and the crystalline lens.

1. THE SCLEROTIC.

The sclerotic (cornea opaca), one of the most complete of the tunics

* By Professor Gaddi, from the injection of the body of a child two years old. "Bullet. delle Scienze mediche," 1844. Cited in Mr. Paget's "Report on the Progrcss of Human Anatomy and Physiology," 1844-45, part 2, in Brit. and Foreign Med. Review.

of the eye, and that on which the maintenance of the form of the organ chiefly depends, is a strong, opaque, unyielding, fibrous structure, composed of bundles of strong white fibres, which interlace with one another in all directions. The membrane covers about four-fifths of the eyeball, leaving a large opening in front, which is occupied by the transparent cornea, and a smaller aperture behind for the entrance of the optic nerve. The outer surface is white and smooth, except where the tendons of the recti and obliqui muscles are inserted into it. The inner surface is of a light brown colour, and rough from the presence of a delicate cellular tissue (*membrana fusca*), through which branches of the ciliary vessels and nerves cross obliquely. The sclerotic is thickest at the back part of the eye, and thinnest in front: the opening for the optic nerve is somewhat smaller at the inner than on the outer surface of the sclerotic. The fibrous sheath of the nerve continued from the dura mater blends with the sclerotic round the margin of the aperture; and the internal covering (*neurilemma*) sends numerous membranous processes which cross the nerve in various directions. In consequence of this latter arrangement, when the nerve is cut off close to the eyeball, the point of its attachment is marked by a circular group of pores (*lamina cribrosa*), in which lies the soft nervous matter, readily removed by maceration.*

2. THE CORNEA.

The cornea (cornea pellucida), fig. 382, [3], is a transparent structure, occupying the aperture left in the fore part of the sclerotic, and forming about one-fifth of the surface of the globe of the eye. It is closely united with the anterior margin of the sclerotic, and the disposition of the two at the place of union varies; in one case the cornea is overlapped by the sclerotic, while in another it appears to be received into a groove in that membrane. The circumference of the cornea is not quite circular in form, the transverse being rather longer than the vertical diameter. The anterior surface is more convex than the sclerotic, and consequently projects beyond it: the actual degree of convexity, however, varies in different persons, and at different periods of life. It is covered by the conjunctiva, already described, fig. 382. The posterior surface of the cornea is concave, assists in bounding the anterior chamber of the eye, and is lined by a very thin and closely adherent film of membrane,† fig. 382,[11] which can be traced no further than the margin of the iris.

The cornea is thicker than any part of the sclerotic membrane; and is for the most part composed of soft and indistinct fibres arranged in several concentric strata. Between the layers is a fine cellular tissue which tears more readily than the substance of the cornea itself, and contains a small quantity of albuminous fluid (*liquor corneæ*). When macerated in water, or steeped in acid, the cornea becomes opaque, with the exception of a layer on the posterior surface, the *elastic cornea*,‡ which retains its transparency perfectly, and appears to undergo no

* A different explanation has been given of these appearances. Some anatomists describe the nerve as passing through a series of holes in the sclerotic itself; and the part of this membrane so perforated is known as the *lamina cribrosa*.

† The thin membrane here alluded to is by some considered as the proper membrane of the aqueous humour, and by others as a layer of epithelium covering that membrane.

‡ This structure has been named by Dr. Jacob the "elastic cornea." By many writers it is considered as a thickened portion of the membrane of the aqueous humour ("capsula aquea cartilaginosa").

change. This layer, when separated from the rest of the cornea, curls up, presents a peculiarly bright and glistening appearance, and breaks with a semi-vitreous fracture. It is covered on the surface next the aqueous humour by the thin membrane already noticed.

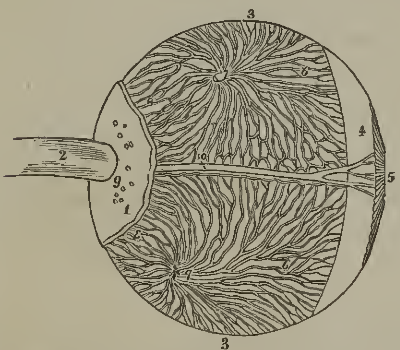
3. THE CHOROID.

The *choroid tunic* (tunica vasculosa) is a dark vascular membrane, lying between the sclerotic and the retina. Pierced behind by the optic nerve, it extends from this point to the ciliary ligament and to the fore part of the hyaloid membrane, where it is thrown into folds round the margin of the crystalline lens. The outer surface, nearly black in colour, is loosely connected with the sclerotic by a layer of cellular tissue, already described, in which are contained the ciliary nerves and the long ciliary arteries and veins; but these, being destined for the supply of the iris, form no part of the choroid. The inner surface of the choroid is soft and villous, highly vascular, and of a deep brown or black colour. In front it is attached to the membrane of the vitreous humour by means of the ciliary processes; elsewhere it is but loosely connected with the outer surface of the retina, —the part named Jacob's membrane.

The choroid is composed of minute ramifications of arteries and veins, united by cellular membrane, and covered, particularly on the inner surface, by a dark brown pigment.

a. The *veins of the choroid*, fig. 377, constitute an outer layer, partially separable from the arterial network, and easily recognised by the direction of the larger vessels. These converge to four nearly equidistant trunks, 377,[1], which pass through the sclerotic about half-way between the margin of the cornea and the entrance of the optic nerve, and pour their contents into the ophthalmic vein. From their whirl-like arrangement they are known as *vasa vorticosa*.

Fig. 377.



A dissection of the eyeball, showing its second tunic and the mode of distribution of the vasa vorticosa of the choroid. After Arnold. 1. Part of the sclerotic coat. 2. The optic nerve. 3, 3. The choroid coat. 4. The ciliary ligament. 5. The iris. 6, 6. The vasa vorticosa. 7, 7. The trunks of the vasa vorticosa at the point where they have pierced the sclerotica. 8, 8. The posterior ciliary veins, which enter the eyeball in company with the posterior ciliary arteries, by piercing the sclerotic at 9. 10. One of the long ciliary nerves, accompanied by a long ciliary vein.

b. The *arteries of the choroid* are furnished by the short ciliary branches of the ophthalmic, fig. 379,[1], which pierce the sclerotic close to the optic nerve, and divide into branches arranged parallel to the axis of the eyeball. Communicating freely, they form a network (*tunica Ruyschiana*) on the inner or concave surface of the venous layer just described, from which they may be distinguished by their smaller size, their more parallel arrangement, and their closer and finer communications. The ultimate distribution of both arteries and veins is at the inner villous surface of the choroid, the great vascularity of which may be shown by injecting either set of vessels.

c. The *pigment* (pigmentum nigrum v. fuscum), of a deep brown, almost black colour, tinges the outer surface of the choroid, as before

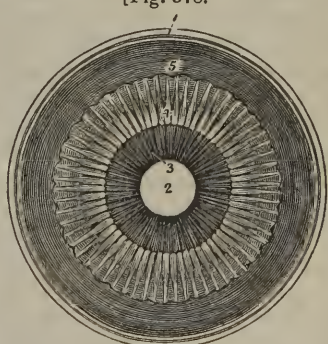
said; but is much more abundant on the inner surface of that tunic, where it forms a continuous layer, which increases in thickness as it approaches the fore part of the eye. It is covered by, and contained in a membrane of peculiar structure (*membrane of the pigment*); and is composed of flat, hexagonal cells, about the 1000th of an inch in diameter, each cell presenting the appearance of a central transparent point (*nucleus*), surrounded by a black margin. In albinoes the colouring matter is deficient; but a central nucleus is still visible.

4. THE ANNULUS ALBIDUS. (CILIARY LIGAMENT.)

Annulus albidus (annulus cellulosus—Zinn; ligamentum ciliare—Winslow), fig. 379, 382.—This is a flat, circular, narrow band of grayish-white substance, lying under the fore part of the sclerotic, close behind the junction of that tunic with the cornea, and serving to connect together several structures in its vicinity. In a transverse section, this band presents a wedge-like form. The thicker margin, directed forwards, assists in bounding the cavity of the aqueous humour, and gives attachment to the circumference of the iris; the posterior or thinner margin of the band is continuous with the fore part of the choroid, though it differs obviously from that membrane in being destitute of pigment, and much less freely supplied with vessels. The greater part of the outer surface of the annulus albidus is only loosely connected to the sclerotic by cellular membrane; but, just behind the margin of the cornea, a firmer union is effected by means of a narrow ring of tough white fibres, to which the term *ciliary ligament* is sometimes more particularly applied. (Krause.) In this situation, and between the annulus, the cornea, and the sclerotic, is inclosed a small circular canal, named the *canal of Fontana*, or sinus circularis iridis, fig. 382. The inner portion of the annulus, less distinctly fibrous, is connected with the ciliary processes, and is traversed by numerous branches of the ciliary nerves, which divide and communicate with each other in its substance before entering the iris.

5. CILIARY PROCESSES. (CORPUS CILIARE.)

[Fig. 378.



The anterior segment of a transverse section of the globe of the eye, seen from within. 1. The divided edge of the three tunics; sclerotic, choroid (the dark layer), and retina. 2. The pupil. 3. The iris, the surface presented to view in this section being the uvea. 4. The ciliary processes. 5. The scalloped anterior border of the retina.—W.]

Whilst the outer cellular layer of the choroid appears to blend with the thin portion of the annulus cellulosus, the vascular elements of the tunic, with the pigment in large quantity, extend inwards behind the iris and in front of the vitreous humour. Approaching the margin of the crystalline lens, this prolongation of membrane is thrown into about 60 or 70 radiated folds (*ciliary processes*), the aggregate of which is called the *corpus ciliare*, fig. 378,[1]. The folds or processes, alternately long and short, are highly vascular, and of a deep brown or black colour. Each ciliary process is broad and flattened behind (*pars non plicata*), fig. 378; but is nar-

rower and more prominent in front (*pars plicata*), fig. 378, where it projects into the posterior chamber, and digitates with somewhat similar radiated folds (*zonula Zinnii*), attached to the fore part of the membrane of the vitreous humour. A sinuous or dentated line (*ora serrata*) marks the commencement of the flat portion of the corpus ciliare from the anterior end of the choroid membrane.

The *blood-vessels of the ciliary processes* are very numerous, and are derived from the fore part of the choroid membrane. At the ora serrata several small arterial branches enter each ciliary process, at first running parallel to each other and communicating sparingly. As they enter the prominent folded portion (*pars plicata*), these vessels become tortuous, subdivide minutely, and inosculate frequently by cross branches. Finally they form short arches or loops, and turn backwards to pour their contents into the radicles of the veins.

On the free border of the fold, one artery, larger than the rest, extends the whole length of each ciliary process, and communicates with a long venous trunk which runs a similar course on the attached surface.

6. THE IRIS.

The *iris*, fig. 378, is a thin, flat, membranous septum, perforated near the centre by a circular aperture (the *pupil*). Hanging vertically in the aqueous humour, it divides unequally the space between the cornea and the crystalline lens. The outer or larger border of the iris is attached to the annulus albidus, immediately behind the margin of the cornea, and in front of the ciliary processes; the inner edge corresponds to the aperture of the pupil, and moves freely in the aqueous humour. The *pupil*, the circular aperture already referred to, is situate a little to the inner or nasal side of the centre of the iris, and varies in size according to the state of contraction or dilatation of the fibres of which that structure is composed.

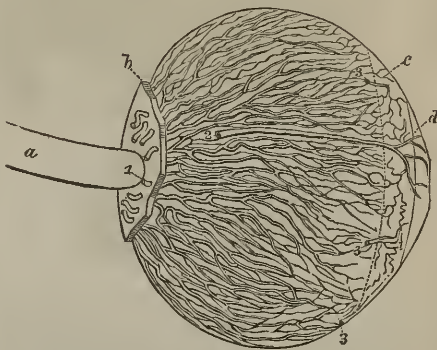
On the anterior surface the iris is marked by radiating lines, and is differently coloured in different persons; the tinge being usually somewhat deeper round the pupil than elsewhere. Closely examined, it presents, about midway between its borders, numerous small irregular elevations, from which little ridges or bands converge towards the centre of the pupil. The posterior surface of the iris itself is colourless, but is hidden by a quantity of black pigment contained under a thin transparent membrane (*uvea*), similar in structure to that already described in the choroid, except that the cells composing it are not quite so accurately formed and regularly arranged. This surface is also marked by lines extending between the pupillary and the ciliary margins, which correspond to radiating bands: they are seen more distinctly after the removal of the uvea.

Structure.—The iris contains radiating and circular fibres, which, though in man presenting no transverse markings, are universally admitted to be muscular in their nature. The radiating fibres are most distinct near the larger margin; they arise, in front of the circular fibres, from the corneal edge of the annulus albidus, and are covered at this point by a reflection of the fine membrane that lines the concave surface of the cornea. They converge towards the pupil, interlacing freely with one another; and finally, much reduced in size, are lost amongst the stronger circular fibres. The circular

fibres are situate more at the back of the iris, and produce, by their contraction, the many transverse folds seen on that surface. They are most numerous close around the pupil (*sphincter pupillæ*), and are least distinct midway between this and the ciliary margin.

Arteries of the iris.—The proper vessels for the supply of the iris are the long ciliary and anterior ciliary arteries.

Fig. 379.



An enlarged view of the arteries of the iris. (From Arnold.)—*a.* Optic nerve. *b.* Sclerotic. *c.* Ciliary ligament. *d.* Iris. 1. Posterior ciliary arteries perforating the sclerotic. 2. Long (external) ciliary artery. 3. Anterior (short) ciliary arteries. (The figure is larger than natural.)

a. The *long ciliary arteries*, fig. 379,[2] two in number, and derived from the ophthalmic, pierce the sclerotic a little before, and on either side of, the optic nerve. Having gained the interval between the sclerotic and choroid coats, they extend horizontally forwards through the cellular tissue (*memb. fusca*) to the annulus albidus. In this course they nearly correspond in direction to the axis of the eyeball, the outer vessel being, however, a little above, and the inner one a little below the level of that line. A short space behind the fixed margin of the iris, each vessel divides into an upper and a lower branch, and these anastomosing with the corresponding vessels of the opposite side of the eye, form a vascular ring (*circulus major iridis*). From this circle smaller branches arise, which converge towards the pupil; and there, freely communicating by transverse offsets from one to another, form a second circle of anastomosis (*circulus minor*).

b. The *anterior ciliary arteries*, fig. 379,[3] several in number, but smaller than the vessels just described, are supplied from the muscular and lachrymal branches of the ophthalmic artery, and pierce the sclerotic about a line behind the margin of the cornea; finally, they divide into branches which join the circulus major.

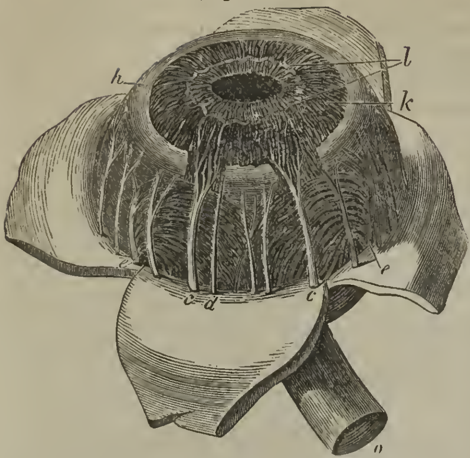
c. Besides these special arteries, numerous minute vessels enter the iris from the ciliary processes, which are highly vascular in their structure.

The *veins of the iris* follow closely the arrangement of the arteries just described. The canal of Fontana appears to communicate with this system of vessels.

The *nerves* for the supply of the iris are named ciliary: they are numerous and large; and before entering the iris, divide in the substance of the annulus albidus.

The *ciliary nerves*, fig. 354, about twenty in number, and derived from the lenticular ganglion and the nasal branch of the ophthalmic division of the fifth nerve, pierce the sclerotic near the entrance of the optic nerve, fig. 380, *c*, *d*, and immediately come in contact with the choroid. They are somewhat flattened in form, are partially embedded in grooves on the inner surface of the sclerotic, and communicate with each other occasionally before entering the annulus albidus. When the sclerotic is carefully stripped from the subjacent structures, these nerves are seen lying on the surface of the choroid. Within the substance of the annulus albidus the ciliary nerves subdivide minutely, a few being lost in the substance of that band, but the greater number passing on to the iris. On account of its connexion with the nerves, Sœmmerring considered the annulus albidus a

[Fig. 380.



Choroid and iris, exposed by turning aside the sclerotica.—c, c. Ciliary nerves branching in the iris. d. Smaller ciliary nerve. e, e. Vasa vorticosa. h. Ciliary ligament and muscle. k. Converging fibres of the greater circle of the iris. l. Looped and knotted form of these near the pupil, with the converging fibres of the lesser circle of the iris within them. o. The optic nerve.—From Zinn.]

ganglionic structure, naming it *circulus gangliformis.*

Pupillary membrane (membrana pupillaris).—In fœtal life a delicate transparent membrane thus named closes the pupil, and therefore completely separates the anterior from the posterior chamber of the aqueous humour. The pupillary membrane contains minute vessels, continuous with those of the iris and of the capsule of the crystalline lens; they are arranged in loops, which converge towards each other, but do not quite meet at the centre of the pupil. At about the seventh or eighth month of fœtal life these vessels gradually disappear; and, in proportion as the vascularity diminishes, the membrane itself is absorbed from near the centre towards the circumference. At the period of birth, often a few shreds, sometimes a larger portion, and occasionally the whole membrane, is found persistent.

7. THE RETINA.

The *retina* (tunica nervea) is a delicate, almost pulpy membrane, continuous with the optic nerve, and thence extending within the choroid nearly to the margin of the crystalline lens. In the living subject it is transparent; but, when slightly decomposed, or when moistened with alcohol or nitric acid, it becomes opaque, and assumes a grayish-white colour.

The retina is in contact by its outer surface with the choroid, and by its inner surface with the hyaloid membrane; but, as far forwards as the posterior margin of the ciliary processes, its connexion with these two structures is very slight, and easily torn through. At the dentated border (*ora serrata*) of the ciliary processes the retina is somewhat thickened, and seems to end in a defined margin. Modern observers, however, (e. g. Valentin and Bidder,) find that it is continued over the inner surface of the ciliary processes; though, from its tenuity, and close adherence to these processes and to the hyaloid membrane, it is with difficulty displayed.*

The concave inner surface of the retina presents at the back of the eye several objects of interest. Directly in a line with the axis of the

* This is seen better in the fœtal, than in the adult eye. It is still undecided whether all, or, if not, which, of the component parts of the retina are thus prolonged.

eyeball is a circular yellow spot (*limbus luteus*), about a line or a line and a half in diameter, and marked in the centre by what appears like a minute hole*—the *foramen centrale* of Sœmmerring. Nearly two lines to the inner or nasal side of the yellow spot is a flattened circular papilla (*colliculus*), corresponding with the situation in which the optic nerve pierces the choroid coat. Between these two points extends a small projection or fold of the retina (*plica centralis retinæ*).

Structure.—Three very different structures are distinguishable in the retina; an outer membrane (the membrane of Jacob), an inner vascular network, and an intermediate stratum of nervous substance.

a. The *membrane of Jacob*† may be raised from the outer surface of the retina by injecting air, or even introducing mercury, beneath it when the eye is under water.

By microscopical observations, this part of the retina has been found to consist of small columns or rods placed at right angles with the surface of the membrane, like the pile of velvet, fig. 381, A. The bodies referred to are of two kinds, one being smaller and more numerous than the other. The small rods are solid and six-sided prisms, narrowed to a point at the end next the choroid, *d*; and they are grouped round the larger bodies. These, which are named by Hannover "twin cones" (*coni gemini*), are shorter than the preceding, and are cleft at the outer end into two short blunt points.

Fig. 381.

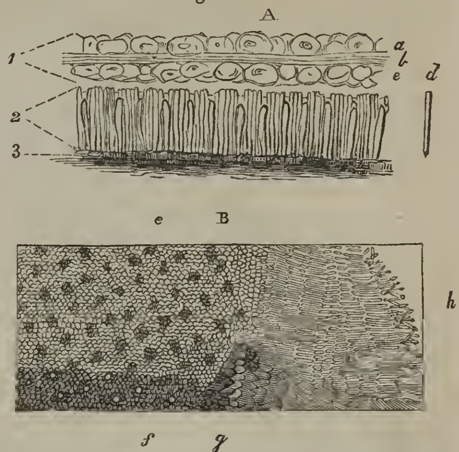


Fig. A. An enlarged plan of the retina, in section. 1. The nervous structure, viz., the nerve-fibres (*b*) between nerve-cells (*a*, *c*). 2. Jacob's membrane. 3. Inner surface of choroid. *d*. One of small pointed bodies of Jacob's membrane.

Fig. B. The outer surface of Jacob's membrane. (From Hannover's *Recherches Microscopiques, &c.*, 1844.)—Opposite *e*, the twin cones are obscurely seen, not being in focus, while, at the lower part of the figure, near *f*, the same bodies are clearly discernible. Towards the right side of the figure, where the objects are disturbed, the twin cones project like papillæ, at *g*, the small rods being in a great measure lost at this place. And these (small bodies) are seen to become horizontal towards the extremity of the object, *h*, where some are in disorder.

Viewed on the outer surface, fig. 381, B, this structure has the appearance of a mosaic pavement. The ends of the little cones are received into small sheaths on the pigment-cells of the choroid; each polygonal pigment-cell corresponding to six or eight of the twin cones, with the more numerous simple rods which surround them, fig. 381, A.

b. Medullary layer.—The essential element of the retina, and that on which depends its capability of receiving the impressions of light, is an expansion of nervous matter derived from the optic nerve. Diverging from the opening in the choroid, the tubular fibres of the optic nerve radiate towards the anterior end of the retina, the fibres becoming more slender, and the spaces between them increasing in width as they advance to the fore part of the eye; and they are covered on the inner and outer surface with a layer of nerve-cells, fig. 381, A.

As regards the mode of termination of the nerve-fibres, anatomists are not agreed. They have been said to form loops, where they end at the anterior

* The appearance of an aperture seems to be produced by the absence at this point of the medullary substance of the retina, the vascular layer being alone continued over it.

† So named after Dr. Jacob, who described it in the *Phil. Trans.*, 1819.

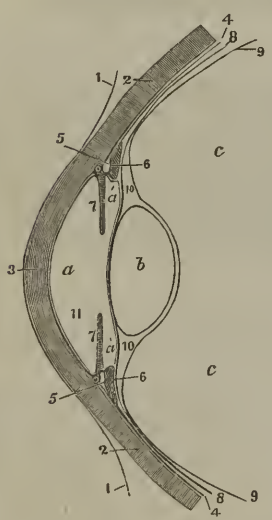
margin of the retina (Valentin); but Hannover states that his observations render it probable that they terminate by free extremities. While the manner of their termination is not determined with certainty, no doubt is entertained as to the place at which it occurs. It is agreed, at least as regards the eye of the lower animals, that none of the fibres end at the bottom of the eye, all reaching the fore part of the organ, as before mentioned.

c. The *vascular layer* (lamina vasculosa retinæ) consists of a fine network of arteries and veins, held together by cellular membrane. It supports the nervous substance of the retina, which may readily be washed from its outer surface after short maceration in water. The *arteries* entering into the formation of this layer are principally derived from the arteria centralis retinæ, a branch of the ophthalmic, which, conducted through the substance of the optic nerve, enters the retina at the centre of the optic papilla and immediately gives off several diverging branches. The posterior ciliary arteries likewise send minute twigs to assist in forming the vascular layer of the retina. The *veins* are considerably larger and more tortuous than the arteries, but follow much the same course and distribution.

8. THE AQUEOUS HUMOUR.

The *aqueous humour* (humor aqueus) is a colourless, transparent, watery fluid, containing a minute quantity of albumen and chloride of sodium in solution, which occupies the interval between the cornea in front, and the crystalline lens and folded ends of the ciliary processes behind. The space thus bounded is partially divided by the iris into two compartments of unequal size (*anterior* and *posterior chambers*), of which that in front of the iris (the anterior chamber) is the larger. In the fœtus, the separation between the two is completed by the membrana pupillaris.

Fig. 382.



Plan of the structures in the fore part of the eye, seen in section.—1. Conjunctiva. 2. Sclerotic. 3. Cornea. 4. Choroid. 5. Annulus albidus: before this is seen the canal of Fontana. 6. Ciliary processes. 7. Iris. 8. Retina. 9. Hyaloid membrane. 10. Canal of Petit (made too large). 11. Membrane of the aqueous humour (too thick). *a.* Aqueous humour: anterior chamber and (*a*) posterior chamber. *b.* Crystalline lens. *c.* Vitreous humour.

The *membrane of the aqueous humour.*—It has been supposed that the aqueous humour is secreted from the surface of a serous membrane, known under this name, lining the walls of this cavity. A thin membrane has already been described as covering the back of the cornea, and thence prolonged, over the edge of the ciliary ligament, to the outer margin of the iris, beyond which it has not been traced. Another fine membrane exists over the posterior surface of the iris and the projecting ends of the ciliary processes; but, as yet, no corresponding structure has been demonstrated either over the capsule of the crystalline lens, or over the fore part of the iris.

9. THE VITREOUS HUMOUR.

The *vitreous humour* occupies about the posterior two thirds of the cavity of the eye, and consists of a clear, thin fluid (*humor vitreus*), inclosed in a fine, transparent membrane (*membrana hyaloidea*). This membrane not only forms a general investment for the whole bulk of fluid, but sends numerous

delicate cellular processes inwards to inclose and support the humour in the form of a semi-solid gelatinous body, called the vitreous body. The *vitreous body* (corpus vitreum) is irregularly spheroidal in form, and presents at its fore part a cup-shaped depression, which lodges the posterior or larger segment of the crystalline lens. On the surface of the corpus vitreum, immediately around this depression, are a number of closely set black lines, so arranged as to form a circle of rays round the margin of the lens. When first exposed, by separating the vitreous body from the ciliary processes, these lines appear of unequal thickness, from the presence of a quantity of adhering pigment; but, when the colouring matter is removed by careful washing, regular projections or folds of membrane are brought into view (*processus ciliares hyaloideæ*), the aggregate of which is called the *zone of Zinn*, or *zonula ciliaris*. Their inner ends do not quite touch the lens, a narrow interval (*zonula lucida*) being left where the hyaloid membrane assists in bounding the posterior chamber of the eye. In their mode of arrangement, these folds resemble the ciliary processes, in the intervals of which they are received, and to which they are attached by cellular tissue. They differ from the ciliary processes, however, in being rather longer and much less prominent.

The hyaloid membrane, for about a line outside the depression for the crystalline lens, consists of two layers, fig. 382,[10]. One of these, immediately inclosing the vitreous humour, passes behind the posterior division of the capsule of the lens; whilst the other, adhering to the ciliary processes, appears to end in the anterior part of the capsule close to the margin. The space left between the two layers of membrane forms round the circumference of the lens a circular passage, the canal of Petit (*canal godronné*),[10] the interior of which is crossed at regular intervals by imperfect membranous septa. When the space is filled with air injected through the outer membrane, an appearance as of a string of beads is produced; the situation of the bands above mentioned is then marked by a series of constrictions, between which the walls of the canal are forced to project.

Behind the ora serrata of the corpus ciliare, the outer surface of the hyaloid membrane is in contact, but is very slightly connected, with the concave surface of the retina; but, in front of the serrated line, it has been seen that the two structures are inseparably united. Opposite the optic papilla is a small aperture in the vitreous body; through which, in the fœtal eye, a minute branch of the central artery of the retina enters. The vessel extends through the middle of the vitreous humour to the back of the crystalline lens; and in this course it is lodged in a tubular process of the hyaloid membrane, called the *hyaloid canal.*

No vessels or nerves have been traced in the membrane of the vitreous humour.

Hannover* has lately investigated the arrangement of the vitreous body and its membrane. After long maceration in chromic acid, he finds it crossed by about 180 delicate membranous septa, disposed somewhat like the segments of the pulp of an orange, with the angles of the inclosed spaces directed towards the axis of

* Müller's Archiv, 1845.

the eyeball. The sectors do not however meet at this line, but leave a cylindrical portion of the vitreous body, of a homogeneous texture, extended between the optic nerve and the centre of the posterior surface of the lens. This is larger in the fœtal than in the adult eye; and through it passes the central artery. The fluid inclosed in the areolæ of the vitreous body becomes slightly gelatinous after this maceration.

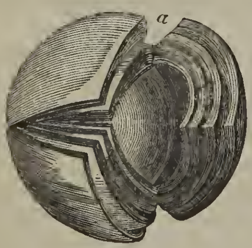
10. THE CRYSTALLINE LENS.

The *crystalline lens*, fig. 382, *b*, is a colourless, transparent, solid body, having the form of a doubly convex lens, situate directly in the axis of vision, and interposed between the aqueous and vitreous humours. Its anterior surface projects within a very short distance of the back of the iris, and assists in bounding the posterior chamber of the eye. The posterior surface, more convex than the anterior, is received into a depression on the fore part of the vitreous body. The circumference is circular, rounded at the margin, and corresponds with the circular canal (canal of Petit) already described in the hyaloid membrane.

The crystalline lens is inclosed in a transparent *capsule*, the character of which differs much on its fore and back part. That portion of the capsule which covers the anterior surface of the lens is thick, and of a peculiar, firm, semi-cartilaginous structure, retaining its transparency and brilliancy (like the layer already described at the back of the cornea) when macerated in water, or even after being immersed in alcohol or dilute nitric acid. The posterior division of the capsule, on the contrary, is thin and membranous, adheres closely to the hyaloid membrane, and is whitened by the action of spirit. The circumference of the capsule is connected with the inner folded ends of the ciliary processes.

The proper substance of the lens adheres but slightly to the inner surface of the capsule; a small quantity of fluid occasionally intervening, which is called the *liquor Morgagni*. In a fresh lens the outer portion is soft and gelatinous. Beneath this is a firmer layer; and in the centre is the hardest part or *nucleus*. After immersion in alcohol, nitric acid, or boiling water, these several parts assume a uniform density, and are then seen to be made up of essentially the same structures. When so treated, the lens may be separated into concentric lamellæ, all of which split in the same way into segments, the apices meeting at two opposite points in the circumference, fig. 383,². These layers are further composed of microscopic fibres arranged side by side, and adhering together by regularly dentated margins. The crystalline lens of the adult seems to be devoid of blood-vessels; but in the fœtus numerous vessels exist in the capsule, which readily admit of injection.

[Fig. 383.



Lens, hardened in spirit and partially divided along the three interior planes, as well as into lamellæ.—Magnified 3½ diameters.—After Arnold.]

The *capsular artery* in the fœtus leaves the arteria centralis retinæ

at the centre of the optic papilla, and crossing through the substance of the corpus vitreum, as already described, enters the posterior portion of the capsule of the lens, where it divides into radiating branches. These form a fine network, turn round the margin of the lens, and extend forward to become continuous with the vessels in the pupillary membrane and the iris. The vessels are contained in the *capsulo-pupillary membrane*, which connects in the fœtus the pupillary edge of the iris with the margin of the capsule of the lens.* This vessel is found only in the fœtal eye.

Changes in the lens by age.—In form, colour, degree of transparency, and density, the lens presents marked differences at different periods of life.

In the *fœtus*, the lens is nearly spherical: it has a slightly reddish colour, not perfectly transparent, and is softer and more readily broken down than at a more advanced age.

In the *adult*, the anterior surface of the lens becomes less convex than the posterior; and the substance of the lens is firmer, colourless, and transparent.

In *old age*, it is flattened on both surfaces; it assumes a yellowish or amber tinge, and is apt to lose its transparency as it gradually increases in toughness and specific gravity.

THE EAR.

The organ of hearing is divisible into three parts: the external ear, the tympanum or middle ear, and the labyrinth or internal ear; and of these the first two are to be considered as accessories or appendages to the third, which is the sentient portion of the organ.

A. THE EXTERNAL EAR.

Included in this term are the pinna,—the part of the outer ear which projects from the side of the head,—and the meatus or passage which leads thence to the tympanum, and is closed at its inner extremity by the membrane interposed between it and the middle ear (membrana tympani).

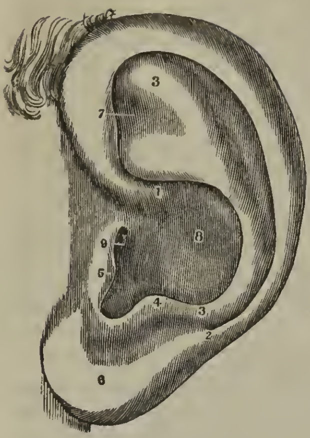
1. THE PINNA.

The *pinna*, or auricle, fig. 384, situate behind the articulation of the lower jaw, and in front of the mastoid process of the temporal bone, is flattened and ovoid, folded at the margins, and irregularly concave towards the opening of the meatus auditorius, round which it is attached. The fixed portion of the pinna is in front of, and a little below its centre; and the free and expanded part extends from this point backwards and outwards, forming an angle with the opposed surface of the cranium.

Though the general form of the auricle is concave, (to fit it for collecting and concentrating the undulations of sound,) the outer surface is marked by several winding ridges and hollows, to which distinct names have been given. The largest and deepest concavity, a

* Some authors (Albinus, Zinn, &c.) state that they have traced vessels from the capsule entering the substance of the lens itself.

Fig. 384.



A view of the left ear in its natural state. 1, 2. The origin and termination of the helix. 3. The antihelix. 4. The antitragus. 5. The tragus. 6. The lobus of the external ear. 7. Points to the scapha, and is on the front and top of the pinna. 8. The concha. 9. The meatus auditorius externus.

little below the centre of the organ, is called the *concha*, fig. 384,[8]; it surrounds the entrance to the external auditory meatus, and is unequally divided at its upper part by a ridge, which is the beginning of the helix. In front of the concha, and projecting backwards over the meatus auditorius, is a conical prominence, the *tragus*,[5] frequently covered with hairs. Behind this, and separated from it by a deep notch (*incisura intertragica*), is another smaller elevation, the *antitragus*,[4] which is directed upwards and forwards, and also assists in bounding the concha. Beneath the antitragus, and forming the lower end of the auricle, is a thick rounded piece called the *lobule*,[6] which is devoid of the firmness and elasticity that characterize the rest of the pinna. The thinner and larger portion of the pinna is bounded by a prominent and incurved margin, the *helix*,[1],[2] which, springing above and rather within the tragus, from the hollow of the concha, surrounds the upper and posterior margin of the auricle, and gradually loses itself in the back part of the lobule. Within the helix is another curved ridge, the *antihelix*,[3] which may be said to begin below, at the antitragus. From this point it sweeps round the hollow of the concha, (forming the posterior boundary of that concavity,) and divides ultimately into two secondary ridges, which diverge as they ascend to the helix.

Fossæ of the pinna.—Between the helix and the single portion of the antihelix is a narrow curved groove, the *fossa of the helix* (fossa innominata, scaphoidea); and between the bifurcations of the upper part of the antihelix is a somewhat triangular depression, the *fossa of the antihelix* (fossa triangularis vel ovalis)[7].—The largest of the fossæ, the concha, has been already described.

The inner or posterior surface of the pinna looks towards the side of the head, and presents several irregularities, the reverse of those just mentioned as on the outer side. The largest prominences correspond to the concha and fossa of the helix; and the principal depression is in the situation of the antihelix.

Structure of the pinna.—The pinna is composed of a thin plate of cartilage covered with skin; but at certain parts the cartilage is deficient, and its place is supplied by fibrous membrane, cellular tissue, and fat. The pinna has also several ligaments and small muscles, which assist in preserving its position and form.

a. The *skin of the pinna* is thin, closely adherent to the cartilage, and supplied with sebaceous follicles, which are most abundant in the hollow of the concha.

b. The *cartilage* presents all the inequalities of surface already described as apparent in the upper part of the pinna; and on this structure, in fact, the irregularities are formed. But the cartilage does not extend into the lobule, which is made up of fat and tough cellular membrane attached to the edge of the cartilage and inclosed in a fold of the skin. Between the tragus and beginning of the helix the cartilage is again deficient, the deep notch there left being bridged over in the natural state by dense fibrous membrane. Behind the antitragus, and between it and the end of the helix, is a smaller notch, which gives to the posterior margin of the auricle a tail-like end, directed towards the lobule. At the fore part of the pinna, opposite the first bend of the helix, is a small conical projection of the cartilage, called the *process of the helix*, to which the anterior ligament is attached. Behind this process is a short vertical slit in the helix; and on the surface of the tragus is a similar but somewhat longer fissure. The substance of the cartilage is naturally brittle, but is much strengthened by a firm fibrous perichondrium.

c. Of the *ligaments of the pinna*, the most important are two which assist in attaching it to the side of the head. The *anterior* ligament, broad and strong, extends from the process of the helix to the root of the zygoma. The *posterior* ligament fixes the back of the auricle (opposite the concha) to the outer surface of the mastoid process of the temporal bone. A few fibres attach the tragus also to the root of the zygoma.

The proper ligaments of the pinna are so placed as to cross over the fissures and intervals left in the cartilage; thus, a strong band of fibrous tissue stretches from the tragus to the beginning of the helix, crossing over the meatus, and completing the boundaries of the concha. Another layer of fibres exists on the inner or cranial surface of the pinna, which assists in maintaining the regular arched form of the auricle.

d. Of the *muscles of the pinna*, those which are attached by one end to the side of the head and move the pinna as a whole, have been already described (vol. i. p. 334): there remain to be examined several smaller muscles, composed of thin layers of pale fibres, which extend from one part of the pinna to another. These are the proper muscles of the organ; and, if sufficiently strong, would act in modifying the form of that part of the external ear. Five small muscles are generally enumerated in each ear, though some writers have increased this number.

1. The *smaller muscle of the helix* (m. minor helicis) fig. 385,[3],[4] is a small bundle of oblique fibres, lying over, and firmly attached to that portion of the helix which springs from the bottom of the concha.

2. The *greater muscle of the helix* (m. major helicis),[1],[2] lies vertically along the anterior margin of the pinna. By its lower end it is attached to the process of the helix; and above, its fibres terminate opposite the point at which the ridge of the helix turns backwards.

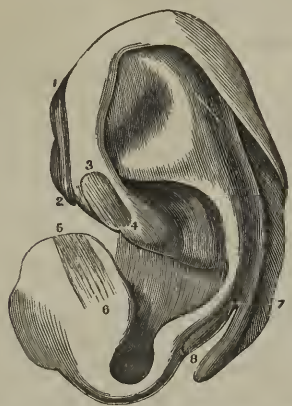
3. The *muscle of the tragus* (m. tragicus),[5],[6] is a flat bundle of short fibres covering the outer surface of the tragus: its direction is nearly vertical.

4. The *muscle of the antitragus* (m. antitragicus),[7],[8] is placed obliquely over the antitragus and behind the lower part of the antihelix. It is fixed at one end of the antitragus, from which point its fibres converge slightly to be inserted into the tail-like extremity of the helix, above and behind the lobule.

5. The *transverse muscle* (m. transversus auriculæ), fig. 386,[5] lies on the inner or

cranial surface of the pinna, and consists of radiating fibres which extend from the back of the concha to the prominence which corresponds with the groove of the helix. The name *obliquus auris* (Tod),[a] has been applied to a few fibres stretching from the back of the concha to the convexity directly above it; but these appear rather to form a part of the transverse muscle.

[Fig. 385. Fig. 386.



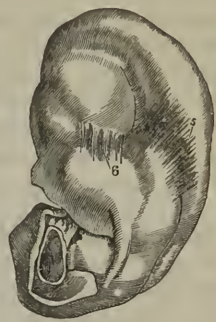


Fig. 385 represents the cartilage of the external ear, with some of its muscles. 1, 2. The helicis major muscle on the front of the helix. 3, 4. The helicis minor muscle. 5, 6. The tragicus muscle on the front surface of the tragus. 7, 8. The antitragicus muscle.—S. & H.]

Fig. 386 represents a view of the muscles on the inner surface of the pinna.—5. The transverse muscle of the auricle. 6. The oblique muscle.

The pinna is supplied with vessels and nerves from several different sources, and these (particularly the vessels) communicate freely on its surface.

e. Arteries of the Pinna.—The *posterior auricular* artery, a branch from the external carotid, is distributed chiefly on the posterior or inner surface, but sends small branches round and through the cartilage to ramify on the outer surface of the pinna. Besides this artery, the auricle receives others (*anterior auricular*) from the temporal in front, and a small artery from the occipital behind.

f. The *veins* correspond much in their course with that of the arteries. They join the temporal vein, and return their blood therefore through the external jugular.

g. Nerves of the Pinna.—The *great auricular* nerve, a branch from the cervical plexus, supplies the greater part of the back of the auricle, and sends small filaments with the posterior auricular artery to the outer surface of the lobule and part of the ear above it. The *posterior auricular* nerve, derived from the facial, after communicating with the *auricular branch of the pneumogastric*, ramifies on the back of the ear and supplies the retrahent muscle. The upper muscles of the auricle receive their supply from the *temporal branches of the same nerve.* The *auriculo-temporal* nerve, a branch of the third division of the fifth nerve, gives filaments chiefly to the outer and anterior surface of the pinna.

2. THE EXTERNAL AUDITORY CANAL.

The external auditory canal (meatus auditorius externus), fig. 387, extends from the bottom of the concha to the membrane of the tympanum, and serves to convey to the middle chamber of the ear the vibration of sound collected by the auricle. The canal is rather more

than an inch in length, and its course inwards is slightly tortuous. Beginning at the concha, it inclines at first upwards and forwards, then makes a little turn backwards, and finally dips downwards and forwards to its termination. The caliber of the passage is smallest about the middle; the outer opening is larger in the vertical diameter, but the tympanic end of the tube is slightly oval in the opposite direction. Owing chiefly to the oblique direction of the membrana tympani, the floor of the meatus is longer than its roof.

Fig. 387.

Horizontal section of the external meatus seen from above. (After Sœmmerring.)—1. Skin of the face in front of the ear. 2. Skin of the head behind the ear. 3. Mastoid process. 4. Osseous part of the external auditory meatus. 5. Hinder part of the pinna, cut through. 6. Lobule. 7. Cartilage of auricle seen in section. 8. External auditory meatus. 9. Membrana tympani. 10. Dura mater.

The meatus is composed of a partly cartilaginous, partly osseous tube, lined by a prolongation of the skin of the pinna.

a. The *cartilaginous* part of the meatus forms somewhat less than half the length of the passage. It is continued from the cartilage of the pinna, and is firmly attached to the rough and prominent margin of the external auditory aperture in the temporal bone. The substance of the cartilaginous tube is continuous with that of the auricle only by a narrow slip; the two parts of the cartilage being nearly separated by two or three deep fissures (*fissures of Santorini*), which are directed across the axis of the canal. There is a large deficiency of the cartilage also at the upper part of the meatus, the space being filled up by dense fibrous membrane.

b. The *osseous portion* of the meatus, which is a little longer and rather narrower than the cartilaginous part, extends through the substance of the temporal bone, from the external auditory foramen to the membrane which forms the outer wall of the tympanum (membrana tympani). At the inner end of the canal is a shallow groove, which extends round the sides and floor of the meatus, but is deficient above; into this the margin of the membrane referred to is inserted.

c. The *skin* of the meatus is continuous with that covering the pinna, but is very thin, and becomes gradually thinner towards the bottom of the passage. It is firmly adherent to the sides of both the cartilaginous and the osseous parts of the canal; and, at the bottom of this, the epidermis is stretched over the surface of the membrana tympani, forming the outer layer of that structure. After maceration in water, or when decomposition is advanced, the cutaneous lining of the passage may be separated and drawn out entire, and then it appears as a small tube closed at one end somewhat like the finger of a glove. The skin is covered with fine hairs, and contains many little oval bodies of a brownish-yellow colour, which are glands for secreting the cerumen or ear-wax (*glandulæ ceruminosæ*). These glands are most abundant about the middle of the canal, where their numerous openings may be seen to perforate the skin.

d. Vessels and nerves.—The external auditory meatus is supplied with arteries from the posterior auricular, internal maxillary, and temporal arteries; and with nerves chiefly from the temporo-auricular branch of the fifth nerve.

B. THE MIDDLE EAR OR TYMPANUM.

The tympanum, or drum, the middle chamber of the ear, is a nar-

row, irregular cavity in the substance of the temporal bone, placed between the inner end of the external auditory canal and the labyrinth. It receives the atmospheric air from the pharynx through the Eustachian tube, and contains a chain of small bones, by means of which the vibrations, communicated at the bottom of the external meatus to the membrana tympani, are conveyed across the cavity to the internal ear,—the sentient part of the organ. The tympanum contains likewise minute muscles and ligaments which belong to the bones referred to, as well as some nerves which end within this cavity, or only pass through it to other parts. The cavity opens, or is continued, into cells (mastoid) of the temporal bone, and through it the atmospheric air reaches those cells.—The boundaries, foramina, and canals of the tympanum will be first described, and then the parts contained in the cavity will come under examination.

1. THE CAVITY OF THE TYMPANUM.

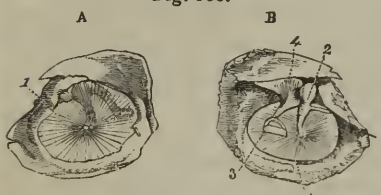
This space is very narrow from without inwards, but measures from before backwards and from above downwards nearly half an inch. For the sake of greater precision in describing the several parts seen on the surfaces of bone which bound the tympanum, it is usual to consider the cavity as presenting a roof and a floor, an outer and an inner wall, an anterior and a posterior boundary.

The *roof* of the tympanum is formed by a thin plate of bone, which may be easily broken through, so as to obtain a view of the tympanic cavity from above; and is situate in the upper part of the petrous portion of the temporal bone near the angle of union with the squamous portion. The *floor* is very narrow, the outer and inner boundaries meeting at an acute angle.

The *outer wall* is formed by a thin semi-transparent membrane (membrana tympani), which closes the inner end of the external auditory meatus, and, to a small extent, by bone.

The *membrana tympani*, fig. 388, A, B, is nearly circular, and is slightly concave on the outer surface. It is inserted into the groove already noticed at the end of the meatus externus, and so obliquely that the membrane inclines towards the anterior and lower part of the canal at an angle of about 45°. The handle of one of the small bones of the tympanum, the malleus, descends between the middle and inner layers of the membrana tympani to a little below its centre, and is firmly fixed to it; and, as the direction of the process of the bone is slightly inwards, the outer surface of the membrane is thereby rendered concave.

Fig. 388.



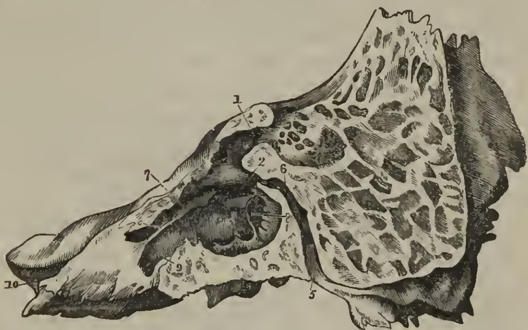
Membrana tympani from the outer (A) and from the inner (B) sides.—1. Membrana tympani. 2. Malleus. 3. Stapes. 4. Incus.

Structure of the Membrane.—Though very thin, the membrana tympani is composed of three distinct structures: a prolongation of the cuticle of the external meatus forms the outer layer; the mucous membrane lining the cavity of the

tympanum furnishes an inner layer; and between those two is the proper substance of the membrane, made up of fine, closely arranged fibres. The greater number of the fibres radiate from near the centre to the circumference; but within these are circular fibres, which are more scattered and indistinct, except close to the margin of the membrane, where they form a dense, almost ligamentous ring. Concerning the precise nature of the fibres of the membrana tympani, anatomists are not agreed.*

Immediately in front of the ring of bone into which the membrana tympani is inserted, a small fissure (*fissura Glasseri*) opens into the glenoid cavity of the temporal bone. It lodges a little muscle or ligament, which is inserted into the long process of the malleus. To the inner side of this fissure is the opening of a small canal,† through which the chorda tympani nerve escapes from the cavity of the tympanum and the skull.

Fig. 389.



A view of the inner wall of the tympanum, from Gordon (Engravings of the Skeleton, 1818).—1. Openings of mastoid cells. 2. Fenestra ovalis. 3 Fenestra rotunda. 4. Promontory. 5. Aqueduct of Fallopius. 6. Junction of the canal for the chorda tympani with the aqueduct. 7. Processus cochleariformis. 8. Canal of the tensor tympani. 9. Eustachian tube. 10. Orifice of the carotid canal.

The *inner wall* of the tympanum, fig. 389, which is formed by the outer surface of the internal ear, is very uneven, presenting several elevations and foramina. Near its upper part is an ovoid, or nearly kidney-shaped opening (*fenestra ovalis*), fig. 389,[2] and fig. 397, which leads into the cavity of the vestibule. This opening, the long diameter of which is transverse, with a slight inclination downwards in front, is occupied in the recent state by the base of the stapes, and the annular ligament connected with that process of bone. Above the fenestra ovalis, and between it and the roof of the tympanum, is a transverse ridge, which corresponds to part of a bony canal (*aqueduct of Fallopius*), containing the portio dura of the seventh nerve: below it is a larger and more rounded elevation, which is caused by the projection outwards of the first turn of the cochlea. This projection is called the *promontory*, or tuber cochleæ;[4] it is marked by several grooves, in which lie the nerves of the tympanic plexus (see note, p. 284).

* Sir E. Home (Philosoph. Trans. vol. xc. p. 1, and cxiii. p. 23) and Meckel have attempted to establish the fact of its muscularity; but this conclusion has not met with the concurrence of other observers.

† It is named, by Cruveilhier, the canal of Huguier. See his Anat. Descript., Paris, 1834, tom. iii. p. 506.

The grooves on the promontory extend between two very small foramina, situate, the one at the upper, and the other at the lower part of the promontory; and these foramina open into two small canals. The upper canal (*canalis tympanicus*, Arnold) extends through the petrous portion of the temporal bone, to its upper surface, and ends close to the hiatus Fallopii. The lower canal leads downwards and inwards, also through the substance of the bone, to the base of the skull, and opens between the outer orifice of the carotid canal and the foramen lacerum jugulare.

Below and behind the promontory, and somewhat hidden by it, is a roundish, or, more correctly, a triangular aperture* (named *fenestra rotunda*),[3] which lies within a funnel-shaped depression. In the dried bone, the fenestra rotunda opens into the scala tympani of the cochlea; but, in the recent state, it is closed by a thin membrane,—*the secondary membrane of the tympanum* (Scarpa).

The *posterior wall* of the tympanum presents at its upper part a larger, and several smaller openings, fig. 389,[1] which lead into irregular cavities (*mastoid cells*) in the substance of the mastoid process of the temporal bone. These cells communicate freely with one another, and are lined by mucous membrane continuous with that which lines the tympanum. Behind the fenestra ovalis, and directed forwards, is a small conical eminence, called the *pyramid*, or eminentia papillaris, fig. 390,[12]. Its apex is pierced by a foramen, from which emerges the tendon of the stapedius muscle. From this foramen may be traced a minute canal, which turns downwards in the posterior wall of the tympanum, and joins obliquely the descending part of the aqueduct of Fallopius.†

The *anterior end* of the tympanum gradually narrows at its lower part towards the apertures of two parallel canals, which are partially separated from each other by a lamina of bone (*processus cochleariformis*), fig. 389,[7]. The upper and smaller canal, about half an inch long, lodges the tensor tympani muscle, fig. 396,[7]; its tympanic orifice is situate directly in front of the fenestra ovalis, and is surrounded by the expanded and everted end of the cochleariform process. The lower and larger of the two canals forms the osseous portion of the Eustachian tube.

The *Eustachian tube* (tuba vel ductus Eustachii) is a canal, formed partly of bone, partly of cartilage and membrane, which leads from the cavity of the tympanum to the upper part of the pharynx. From the tympanum it is directed forwards and inwards, with a little inclination downwards; and its entire length is from an inch and a half to two inches. The *osseous* division of the Eustachian tube, fig. 389,[9] begins in the lower and fore part of the tympanum, below the cochleariform process, and gradually contracting in diameter as it extends forwards, ends in a jagged opening at the anterior margin of the petrous portion of the temporal bone, close to the angle of junction with the squamous portion. The *anterior* part of the tube, fig. 390,[5] is formed of a triangular piece of cartilage, the edges of which are

* Haller described it as a canal having two openings, rather than a mere foramen. ("Elementa Physiologiæ," lib. xv. § 26. See also Scarpa, "De structura fenestræ rotundæ, et de tympano secundario anatomicæ observationes." Mutinæ, 1772.)

† Described by Huguier in Cruveilhier, (Anat. Descript. tom. iii. p. 501.)

slightly curled round towards each other, leaving an interval at the outer side, in which the canal is completed by dense fibrous membrane. Narrow behind, the tube gradually expands till it becomes wide and trumpet-shaped in front; and the anterior part is compressed from side to side, and is fixed to the inner plate of the pterygoid process of the sphenoid bone. The anterior opening is oval in form, and is placed obliquely at the side and upper part of the pharynx, into which its prominent margin projects behind the lower meatus of the nose, and above the level of the hard palate. Through this aperture the mucous membrane of the pharynx enters, and is continuous with that which lines the cavity of the tympanum.

2. SMALL BONES OF THE EAR.

Three small bones (ossicula auditûs) are contained in the upper part of the tympanum, fig. 390 : of these, the outermost (malleus) is attached

Fig. 390.

A view of the inner wall of the tympanum and Eustachian tube in the recent state, with the small bones in their natural position. (Arnold.)—1. Styloid process of the temporal bone. 2. Mastoid process. 3. Fore part of the pars petrosa. 4. Pharyngeal portion of the Eustachian tube. 5. Its cartilaginous part. 6. Its mucous surface. 7. Carotid canal. 8. Fenestra rotunda. 9. Malleus. 10. Incus. 11. Stapes. 12. Pyramid and stapedius. The suspensory ligament of the malleus, and the upper and posterior ligaments of the incus are also seen.

to the membrana tympani, fig. 388 ; the innermost (stapes) is fixed in the fenestra ovalis ; and the third (incus), placed between the other two, is connected to both by minute joints, fig. 395. The first two are placed in nearly a vertical direction, the last is horizontal. The result is a species of angular and jointed connecting rod between the outer and inner walls of the tympanic cavity, which serves to communicate vibrations from the membrana tympani to the fluid contained in the vestibule of the internal ear.

MALLEUS.

a. The *malleus* has been named from a fancied resemblance in form to a hammer. It consists of a central thicker portion, with processes of different lengths. At the upper end of the bone is a rounded *head* (capitulum), fig. 391,[6]

which is lodged in the upper part of the tympanum, above the membrana tympani, fig. 388, B; and presents internally and posteriorly an irregularly oval plane surface, fig. 391, covered with cartilage, for articulation with the incus.

[Fig. 391.

Fig. 392.

Fig. 393.

Fig. 394.

Fig. 391. A full view of the malleus. 1. Processus longus (too thick). 2. Processus brevis. 3. The manubrium. 4. The neck. 5. The head of the malleus; near the figure is seen a small articulating face for the incus.

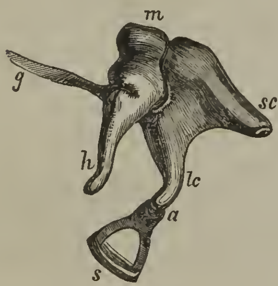
Fig. 392. A view of the incus. 1. Its body, with the articular face for the convex head of the malleus. 2. Its short or horizontal process. 3. Its long or perpendicular process. 4, 4. The head of this process for articulating with the head of the stapes. It is also called the orbiculare.

Fig. 393. A front view of the stapes. 1, 2. The head of the stapes with its articulating face placed obliquely. 3. Its neck. 4. Its anterior crus. 5. Its posterior crus more curved than the other. 6. Its base, the part which covers the fenestra ovalis.

Fig. 394. A magnified view of the stapes from above, showing the fenestrum in its base. 1. Cartilaginous articular face, with the orbiculare attached to it. 2. Its anterior crus. 3. Its posterior crus. 4, 4. Its base slightly open.—S. & H.]

Below the head is a constricted part or *neck* (cervix),[4]; and beneath this another slight enlargement of the bone, to which the processes are attached. The *handle* (manubrium) of the malleus,[3] is a tapering and slightly twisted process, which is compressed from before backwards to near its point, where it is flattened in the opposite direction. The handle of the malleus is directed nearly vertically, with a slight inclination forwards and inwards, and is received between the middle and inner layers of the membrana tympani, to which it is closely attached. At the fore part and near the base of this process is a small elevation, to which the tensor tympani muscle is attached, fig. 396. The *long process* (processus gracilis, fig. 391,[1]) is a very slender spine of bone, often broken off in removal from the tympanum, which projects at nearly a right angle from the neck of the malleus, and extends thence obliquely downwards and forwards to the Glasserian fissure. Its end is flattened and expanded, and is connected generally by ligamentous fibres and sometimes by bony matter to the sides of the fissure. The *short process* (processus brevis vel obtusus), fig. 391,[2], is a low conical eminence springing from beneath the cervix, and projecting outwards towards the upper part of the membrana tympani. It is in contact with the middle layer of that membrane, and is not, therefore, so completely invested, as the greater part of the malleus, by the mucous lining of the tympanum.

[Fig. 395.



Ossicles of the left ear articulated, and seen from the outside and below. *m.* Head of the malleus, below which is the constriction, or neck. *g.* Processus gracilis, or long process, at the root of which is the short process. *h.* Manubrium, or handle. *sc.* Short crus; and *lc*, long crus of the incus. The body of this bone is seen articulating with the malleus, and its long crus, through the medium of the orbicular process, here partly concealed, *a*, with the stapes. *s.* Base of the stapes. Magnified three diameters. From Arnold.]

INCUS.

b. The *incus*, fig. 392, has been compared to an anvil in form (hence its name); but it perhaps resembles more a bicuspid tooth with the fangs widely separated. It presents a body and two processes. The *body* of the incus, [1], is somewhat square, and is situate in the upper and back part of the tympanum, above the margin of the membrana tympani. It presents a deeply concave articular surface, which is directed upwards, forwards, and a little outwards, and receives the head of the malleus. The surfaces of the little ball-and-socket joint thus formed are tipped with articular cartilage and covered by a synovial membrane. The *shorter* of the two processes (crus breve) of the incus, [2], projects nearly horizontally backwards from the upper part of the body of the bone. The end is rough, and is often connected by ligamentous fibres with the posterior wall of the tympanum near the entrance of the mastoid cells. The *long process* (crus longum), [3], tapers rather more gradually, and is slightly bent as it descends nearly vertically behind the handle of the malleus. On the inner surface of its point is a rounded tubercle, tipped with cartilage (processus lenticularis): this tubercle, which articulates with the head of the stapes, has been described as a separate bone, under the name of *os orbiculare* seu *lenticulare*.

STAPES.

The *stapes*, the third and innermost bone of the ear, fig. 393, is in shape remarkably like a stirrup (whence its name), and is composed of a head, a base, and two crura. The *head*, [1], is directed outwards towards the membrana tympani, and has on its end a slight depression, covered with cartilage, which articulates with the lenticular process of the incus. The *base*, [6], is placed horizontally in the fenestra ovalis, to the margin of which it is fixed by ligamentous fibres. The form of the base (fig. 394) is irregularly oval, the upper margin being curved, while the lower one is nearly straight. The crura of the stapes diverge from a constricted part (*neck*) of the bone, immediately behind the head, and are attached to the outer surface of the base near its extremities. The anterior crus is the shorter and straighter of the two. The crura, with the base of the stapes, inclose a small triangular space, which in the recent state is occupied by a thin membrane, stretched across. A shallow groove runs round the opposed surfaces of the bone, and into this the membrane is received.

3. LIGAMENTS AND MUSCLES OF THE TYMPANUM.

The small bones above described are connected with each other, and attached to the walls of the tympanum, by ligamentous fibres, in such a manner as to admit of a certain degree of movement at each of the points at which two bones come into contact. By this means apparently the vibrations of the membrana tympani are transmitted to the internal ear without that sudden shock which would be inevitable were the bony communication rigid and unyielding.

With regard to the connexion between the several bones of the tympanum, it has already been said that the head of the malleus is received into a cup-shaped depression in the body of the incus, and that the lenticular process of the incus articulates with the head of the stapes. The surfaces of bone entering into the formation of these small joints are tipped with cartilage, covered by synovial membrane, and surrounded by short ligamentous fibres in the form of capsular ligaments.

The attachment of the bones of the ear to the walls of the tympanum is effected partly by the reflections of the mucous membrane lining that cavity, but chiefly by ligaments and muscles. Owing to the minuteness of these structures, and their being covered by vascular mucous

membrane, it is difficult to recognise with certainty their exact nature; and hence much difference of opinion existsa mongst authors as to the number of the muscles of the tympanum. Sœmmerring * describes four; Todd † increases the number to nine; but the general tendency of modern anatomical investigations is to throw doubts on the muscular nature of two or three of those even mentioned by Sœmmerring.

The greater number of these structures (muscular and ligamentous) are attached to the malleus.

Tensor tympani, fig. 396,[7] (musculus internus mallei).—This is the only muscle of the tympanum concerning the nature of which there is no dispute. It consists of a long, tapering, fleshy part, and a slender tendon. The muscular fibres arise from the cartilaginous end of the Eustachian tube and the adjoining surface of the sphenoid bone, and from the sides of a small canal, already described, above and parallel to the osseous portion of the Eustachian tube. In this canal the muscle is conducted nearly horizontally backwards to the fore part of the cavity of the tympanum. Immediately in front of the fenestra ovalis the tendon of the muscle bends at nearly a right angle over the processus cochleariformis, and passes thence outwards to be inserted into the fore part of the handle of the malleus, near its root and below the processus gracilis.

Fig. 396.

A view of the contents of the tympanum seen from above, after cutting away the roof of the cavity and part of the pars petrosa of the temporal bone — 1. Inner semicircular canal opened. 2. Cochlea exposed. 3. Eustachian tube. 4. Caput mallei. 5. Incus. 6. Stapes. 7. Tensor tympani. 8. Stapedius.

The *laxator tympani major* of Sœmmerring is by many anatomists believed to be fibrous tissue covered by mucous membrane, and supplied with vessels which give it somewhat the appearance of muscular structure. Under the idea that it is simply fibrous, this has been named the *anterior ligament of the malleus*. Arising from the spinous process of the sphenoid bone, and slightly from the cartilaginous part of the Eustachian tube, it is directed backwards and inwards, passes through the Glasserian fissure, and is inserted into the neck of the malleus, just above the root of the processus gracilis.

The *laxator tympani minor* of Sœmmerring (*posterior ligament of the malleus*—Lincke) is made up of reddish fibres, which are fixed at one end to the upper and back part of the external auditory meatus, pass forwards and inwards between the middle and inner layers of the membrana tympani, and are inserted into the outer border of the handle of the malleus, and the short process near it.

The *suspensory ligament of the malleus*‡ (ligamentum teres vel superius) consists of a little round bundle of fibres, which descend perpendicularly from the roof of the tympanum to the head of the malleus. It is about two lines in length.

* Sœmmerring, S. T. Icones Organi Auditûs Humani.
† Todd, D. The Anatomy and Physiology of the Organ of Hearing, &c. Lond. 1832.
‡ Seen in fig. 390, over number 9.

The incus has no muscles attached to it. This bone is kept in position chiefly by its attachments, already noticed, with the malleus and stapes.

It is likewise suspended by a small ligament (the *posterior ligament of the incus*, fig. 390), which extends from near the point of the short crus directly backwards towards the posterior wall of the tympanum, where it is attached to the side of the pyramid, near the entrance to the mastoid cells. Arnold moreover describes an upper ligament of the incus, fig. 390, which attaches the upper part of the incus (near its articulation with the malleus) to the roof of the tympanum. Its direction is parallel with, and close behind the suspensory ligament of the malleus.

The stapes is provided with a little muscle which acts on the outer end or head, and a ligament which fixes the base in such a manner as to permit a limited degree of motion of the whole bone.

The *stapedius muscle*, fig. 396,[8] is lodged in the hollow of the pyramid, from the sides of which its fibres arise. The tendon pierces the aperture at the apex of that little elevation, and passing forwards, is inserted into the neck of the stapes, close behind the articulation of that bone with the lenticular process of the incus. The muscularity of the stapedius has been questioned by some anatomists. Sœmmerring figures a branch of the portio dura supplying it. A very slender spine of bone has been found occasionally in the tendon of the stapedius in man; and a similar piece of bone, though of a rounder shape, exists constantly in the horse, the ox, and other animals.

The *annular ligament of the stapes* (ligamentum orbiculare vel annulare baseos stapedis) connects the base of the bone to the margins of the foramen (fenestra ovalis), in which it is lodged. The fibres of the ligament are covered on the outer side by the mucous lining of the tympanum, and on the inner side by the membrane of the vestibule.

4. THE LINING MEMBRANE OF THE TYMPANUM.

The tympanum is lined throughout by a thin, vascular, fibro-mucous membrane, which is continuous with the mucous membrane of the pharynx through the Eustachian tube, and is further prolonged from the tympanum backwards into the mastoid cells. It adheres closely to the walls of the cavity, forms the inner layer of the membrana tympani, assists in covering over the fenestra rotunda, and gives a more or less complete investment to the bones and muscles of the tympanum, and to the nerves which cross that cavity. The mucous membrane which lines the cartilaginous part of the Eustachian tube resembles much the membrane of the pharynx, with which it is immediately continuous. It is thick, villous, and highly vascular, covered with vibratile cilia, and provided with many simple mucous glands which pour out a thick secretion. In the osseous part of the Eustachian tube, however, this membrane gradually changes its character; and in the tympanum and mastoid cells it is paler, thinner, and less vascular, presents no traces of mucous follicles or cilia, and secretes a less viscid, yellowish fluid.

5. VESSELS AND NERVES OF THE TYMPANUM.

The arteries of the tympanum, though very small, are numerous, and are derived from several branches of the external and internal carotid.

The fore part of the cavity is supplied chiefly by the *tympanic branch of the internal maxillary*, which enters by the fissure of Glasser. The back part of the cavity, including the mastoid cells, receives its arteries from the *stylo-mastoid branch of the posterior auricular artery*, which is conducted to the tympanum by the aqueduct of Fallopius. These two arteries also form a vascular circle round the margin of the membrana tympani. The smaller anastomosing arteries of the tympanum are, the *petrosal branch* of the middle meningeal, which enters through the hiatus Fallopii; the *Vidian branch* of the descending palatine, through the Vidian canal; branches through the bone from the *internal carotid* artery, furnished from that vessel whilst in the carotid canal; and occasionally a twig along the Eustachian tube from the *ascending pharyngeal* artery.

The *veins* of the tympanum pour their contents through the middle meningeal and pharyngeal veins, and through a plexus near the articulation of the lower jaw, into the internal jugular vein.

Nerves.—The tympanum contains several nerves; for, besides those which supply the parts of the middle ear, there are several which merely serve to connect nerves of different origin.

The lining membrane of the tympanum is supplied by filaments from the plexus (tympanic plexus), which occupy several small and shallow grooves described as being on the inner wall of the cavity, and particularly on the surface of the promontory, (see page 284.)

The *tympanic plexus* is formed by the communications between, 1st, the tympanic branch (*nerve of Jacobson*) from the petrous ganglion of the glosso-pharyngeal; 2d, a *filament from the carotid plexus* of the sympathetic; 3d, a branch which joins the *great superficial petrosal nerve*, from the Vidian; 4th and lastly, the *small superficial petrosal nerve*, from the otic ganglion.

These nerves having been already described with the trunks from which they are severally derived, it is only necessary to indicate them here as they are seen in the tympanum. The nerve of Jacobson, fig. 359,[4] enters the tympanum by a small foramen near its floor, which forms the upper end of a short canal in the petrous portion of the temporal bone, beginning at the base of the skull between the carotid foramen and the jugular fossa. The nerve from the carotid plexus,[5] is above and in front of this, and passes through the bone directly from the carotid canal. The branch to the great superficial petrosal nerve,[8] is lodged in a canal which opens on the inner wall of the tympanum in front of the fenestra ovalis. The small superficial petrosal nerve,[9] also enters at the fore part of the cavity beneath the canal for the tensor tympani.

The tensor tympani muscle receives its nerve from the otic ganglion, fig. 359,[10]; and the stapedius is figured by Sœmmerring as supplied by a filament from the facial nerve. The chorda tympani is not destined for the supply of any part of the middle ear; it is invested in a tubular reflection of the lining membrane of the tympanum, and its course across the cavity has been described, (see page 280.)

C. THE INTERNAL EAR, OR LABYRINTH.

This, which is the essential or sensory part of the organ of hearing, is contained in the petrous portion of the temporal bone. It is made up of two very different structures, known respectively as the osseous and the membranous labyrinth.

1. The *osseous labyrinth* is lodged in the cancellated structure of the temporal bone, and presents, when separated from this, the appearance shown in the enlarged figure (397). It is incompletely divided into three parts, named respectively the vestibule, the semicircular

canals, and the cochlea. They are lined throughout by a thin serous membrane, which secretes a clear fluid (perilymph).

2. The *membranous labyrinth* is contained within the bony labyrinth, and, being smaller than it, a space intervenes between the two, which is occupied with the perilymph just referred to. This structure supports numerous minute ramifications of the auditory nerve, and incloses a liquid secretion (endolymph). The parts thus briefly noticed will now be described in detail.

1. THE OSSEOUS LABYRINTH.

a. The *vestibule*, fig. 397,[7] forms a sort of central chamber of the labyrinth, which communicates in front with the cochlea, behind with the semicircular canals, on the outer side with the cavity of the tympanum, and on the inner side with the meatus auditorius internus. The vestibule is irregularly ovoidal in shape, and is slightly flattened or compressed from without inwards. The outer wall, which sepa-

Fig. 397.

Fig. 398.

Fig. 397. A view of the labyrinth of the left ear of a fœtus of 8 months, as seen from above.—Magnified 4 diameters. 1, 2, 3, The cochlea. 1, 1. Its first turn. 2, 2. Its second turn. 3, 3. Its third or half turn, and apex or cupola. 4. The fenestra rotunda. 5. The fenestra ovalis. 6. The groove around it. 7, 7. The vestibule. 8, 9, 10. The posterior semicircular canal, with its ampulla at 8. 11, 11. The superior semicircular canal. 12. The external semicircular canal.—S. & H.]

Fig. 398. An outline, of the natural size, of figure 397.

rates it from the cavity of the tympanum, presents the fenestra ovalis,[6] already noticed, which is closed, in the recent state, by the base of the stapes and its annular ligament. Near the upper part of the inner wall is an ovoid depression, called the *fovea hemielliptica*, fig. 399, *o*, (sinus ovatus—Sœmmerring); and beneath this is another rounder pit, the *fovea hemispherica*, *r*, (sinus rotundus—Sœmmerring). Between the two hollows extends a transverse ridge, which is named the *crista vestibuli*, or eminentia pyramidalis. Both the ridge and the hemispherical fossa are pierced with many small holes, which serve to transmit branches of the auditory nerve from the internal auditory meatus. Behind the fovea hemispherica is the small oblique opening of a canal, *a, v* (the *aqueduct of the vestibule*,) which extends to the posterior surface of the petrous portion of the temporal bone; it transmits a small vein in a tubular prolongation of membrane. At the back part of the vestibule are five round apertures, leading into the semicircular

canals; and at the lower and fore part of the cavity is a larger opening, that communicates with the scala vestibuli of the cochlea (*apertura scalæ vestibuli*).

b. The *semicircular canals*, fig. 397,[9 11 12] are three bony tubes, situate above and behind the vestibule, into which they open by five apertures, already noticed. Each tube is bent so as to form the greater part of a circle; and each presents, at one end, a slightly dilated part, called the *ampulla*. In other respects, namely, in position with regard to the vestibule, in direction, and in length, the canals differ from one another. The *superior* semicircular canal, fig. 397,[11] is *vertical* in direction; and, rising above any other part of the labyrinth, forms a smooth round projection on the upper surface of the petrous portion of the temporal bone. The anterior or dilated end of the canal opens by a distinct orifice into the upper part of the vestibule; whilst the opposite extremity joins the corresponding non-dilated end of the posterior vertical semicircular canal, and enters by a common aperture with it into the back part of the vestibule. The *posterior* semicircular canal, fig. 397,[9] also *vertical* in direction, is the longest of the three tubes. The ampulla of this canal is attached to the lower and back part of the vestibule; and the cylindrical crus joins the common trunk above described. The *external* semicircular canal, fig. 397,[12] is placed *horizontally*, and opens by two distinct orifices into the upper and back part of the vestibule. This canal is shorter than either of the other two.

Fig. 399.

Fig. 400.

Fig. 399. Interior of the osseous labyrinth. V. Vestibule. *a*, *v*. Aqueduct of the vestibule. *o*. Fovea hemielliptica. *r*. Fovea hemispherica. S. Semicircular canals. *s*. Superior. *p*. Posterior. *i*. Inferior. *a*, *a*, *a*. The ampullar extremity of each. C. Cochlea. *ac*. Aqueduct of the cochlea. *sv*. Osseous zone of the lamina spiralis, above which is the scala vestibuli, communicating with the vestibule. *st*. Scala tympani below the spiral lamina. From Sœmmerring.

Fig. 400. Osseous labyrinth of the barn owl (Strix flammea.) (From Breschet.)—1. Semicircular canals. 2. Vestibule. 3. Cochlea.

c. The *cochlea*, fig. 397,[1 2 3] is the third and most anterior division of the internal ear. When the dense bony substance, in which it lies embedded, is picked away, the cochlea presents the form of a blunt

cone, the base of which is turned towards the internal auditory meatus, whilst the apex is directed outwards, with an inclination forwards and downwards. The surface of the cone is marked by a spiral groove, which gives to this part of the labyrinth somewhat the appearance of a spiral shell—whence its name.

A general idea of the plan on which this more complex portion of the labyrinth is constructed, may be obtained by first supposing it to be a gradually tapering bony tube of a certain length, which is divided into two compartments by a partition (partly bone and partly membrane), the two compartments being distinct, except at the end, where they communicate one with the other in consequence of the deficiency of the partition. Such is the simplest idea of this division of the internal ear, and it actually exists in this form in the ear of birds. See fig. 400,[3].

The names given to certain parts may be indicated here. The partition is called the lamina spiralis, and the reason for the term "spiral" will presently appear; the two half-tubes, which are termed scalæ, are distinguished by the addition of the names of the cavities (tympanum and vestibule) into or towards which they open respectively; the place at which the half-tubes join is the helicotrema, and the end of the tube covering this over is the cupola.

In order to convert the straight tube now noticed into the spiral one named cochlea, it must be supposed to be coiled on itself so as to intercept a conical space—the first turn making much the widest sweep, fig. 397; and this space is occupied by the spongy substance of the temporal bone. The added bony matter, which supports the coils of the tube, together with the inner surface of the tube itself, constitutes what is called the modiolus.

The *spiral canal of the cochlea* (canalis spiralis cochleæ), fig. 401,[3 4] is about an inch and a half long, and about the tenth of an inch in diameter at the broadest part, which is turned towards the cavity of the vestibule. From this point the canal makes two turns and a half round the central pillar, (from left to right in the right ear, and in the

Fig. 401.

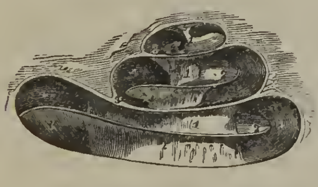


Fig. 402.

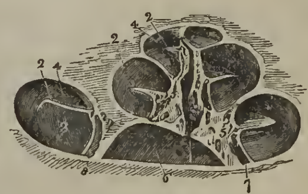


Fig. 401. Diagram showing the form and structure of the dry cochlea (laid open.)—1. Modiolus. 2. Lamina spiralis. 3. Scala tympani. 4. Scala vestibuli.

Fig. 402. Section of the cochlea. (From Arnold.)—1. Foramen centrale modioli. 2. Lamina spiralis ossea. 3. Scala tympani. 4. Scala vestibuli. 5. Cellular substance of the modiolus.

opposite direction in the left ear,) and ends by an arched and closed extremity called the *cupola*, which forms the apex of the whole cochlea. The first coil, being composed of the largest portion of the tube, nearly hides the second turn from view; and, bulging somewhat into the tympanum, forms the round elevation on the inner wall of that cavity, called the promontory.

The *modiolus* (columella cochleæ), fig. 401,[1] forms the central pillar or axis round which turn the spiral canal and the spiral lamina. It is much thicker within the first turn of the cochlea than at any other part; rapidly diminishes in size through the second coil; and again

slightly expands within the last half-turn or cupola, fig. 401. The outer surface of the modiolus is dense, being, in fact, composed of the walls of the spiral canal; but the centre is soft and spongy, and is pierced by many small canals for the passage of the auditory nerve from the inner meatus to the lamina spiralis, fig. 402. One of these canals, larger than the rest (*canalis centralis modioli*), runs from the base through the centre of the modiolus to the apex, where it expands slightly, and forms what has been named the *infundibulum*.

The *spiral lamina* (lamina spiralis), fig. 402, is, in the dried state, a thin, flat, osseous plate, growing from and winding round the modiolus, and projecting into the spiral canal, so as partially to divide it into two scalæ. In this state the separation of the scalæ is incomplete; firstly, because the osseous lamina is deficient at the apex of the cochlea, where it forms a sort of open hook-like termination (*hamulus*); and, secondly, because its free margin does not, at any part, reach much further than about two-thirds of the distance between the modiolus and the outer wall of the spiral canal. This free edge of the osseous lamina gives attachment in the recent state to a membranous septum (membranous zone), which is continued outwards to be inserted into the circumference of the spiral canal. Within the attached portion of the osseous lamina, and therefore winding close round the modiolus, is a small canal, named by Rosenthal the *canalis spiralis modioli*.

The osseous lamina is thin and dense near its free margin; but near the modiolus it is composed of two denser outer plates, inclosing a more open and spongy structure, in which run numerous small canals, continuous, but running at right angles with the canals in the centre of the modiolus. In these are lodged filaments of the auditory nerve.

The *scalæ* are the two passages into which the general canal of the cochlea is divided by the lamina just described. One of these, the *scala tympani*, fig. 402,[3], communicates with the cavity of the tympanum by the fenestra rotunda, which, in the recent state, is closed by the secondary membrana tympani, and with the scala vestibuli by an opening (*helicotrema*) left at the apex of the cochlea, in consequence of the deficiency of the lamina spiralis in the last half-turn of the canal. In the wider part of the tympanic scala, and close to the fenestra rotunda, is the orifice of a small canal, fig. 399, *a*, *c* (*aqueductus cochleæ*), which extends downwards and inwards through the substance of the petrous part of the temporal bone to near the jugular fossa, and transmits a small vein. The surface of the spiral lamina which looks towards this scala is marked with numerous transverse striæ.

The *scala vestibuli*, fig. 402,[4], (rather narrower than the scala tympani in the first turn of the cochlea,) opens freely into the cavity of the vestibule, and communicates, as already described, with the scala tympani at the apex of the modiolus. The transverse grooves on the surface of the lamina which is directed towards the scala are less marked than those in the scala tympani.

d. The lining Membrane of the osseous Labyrinth.—This is a thin

fibro-serous membrane, which closely adheres to the whole inner surface of the several parts of the labyrinthic cavity just described. From the vestibule it is prolonged directly into the semicircular canals, the scala vestibuli of the cochlea, and the aqueductus vestibuli; and through the opening of the helicotrema it is further continued into the scala tympani and aqueductus cochleæ. It has, however, no communication with the lining membrane of the tympanum, being, like that membrane, stretched across the openings of the round and oval fenestræ. The outer surface of the lining membrane of the labyrinth is rough, and adheres closely, like periosteum, to the bone; the inner surface is pale and smooth, is covered with epithelium like that of the arachnoid, and secretes a thin, slightly albuminous or serous fluid. This secretion, first described by Cotunnius, and hence known to anatomists as the *liquor Cotunnii*, has been called by Blainville the *perilymph*. It separates the membranous from the osseous labyrinth in the vestibule and semicircular canals, occupies alone the cavities of the scalæ in the cochlea, and is continued into the aqueducts as far as the membrane lining these passages remains pervious.*

2. THE MEMBRANOUS LABYRINTH.

Within the osseous labyrinth, and separated from its lining membrane by the perilymph, is a membranous structure, which serves to support the ultimate ramifications of the auditory nerve. In the vestibule and semicircular canals this membrane has the form of a rather complex sac, and incloses a fluid called the endolymph: in the cochlea the analogous structure merely completes the lamina spiralis, and is covered by the membrane which lines the general cavity of the osseous labyrinth.

a. The part of the *membranous labyrinth* contained *in the vestibule* (*membranous vestibule*) consists of two rounded portions, which, though closely connected together, appear to be distinct sacs. The larger of the two, the *common sinus* (sinus communis vel utriculus), fig. 403,[1], is of an oblong form, and slightly flattened from without inwards. It is lodged in the upper and back part of the osseous vestibule, and fills the depression called the fovea hemielliptica. Opposite the crista vestibuli several small branches of the auditory nerve enter from the foramina in the bone; and here the walls of the common sinus are thicker and more opaque than elsewhere. The cavity of the common sinus communicates with that of the membranous semicircular canals by five orifices, and contains, besides endolymph, a small mass of calcareous matter. The smaller vestibular bag, named the *saccule*, fig. 403,[12], is more nearly spherical than the common sinus, but, like it, is somewhat flattened. The saccule is situated in the lower and fore part of the cavity of the osseous vestibule, close to the opening from the scala vestibuli of the

* According to Breschet and Huschke, the lining membrane of the labyrinth is, in fœtal life, continuous with the dura mater and arachnoid of the skull; and the aqueducts in the adult mark the points of communication, nearly obliterated by the development of the bone and the gradual closing in of the osseous labyrinth.

cochlea, and is received into the hollow of the fovea hemispherica, from the bottom of which many branches of nerve enter. The sacculus appears to have a cavity distinct from that of the utricle, but is filled with the same thin and clear fluid (endolymph), and contains a similar cretaceous body.

b. The *membranous semicircular canals*, fig. 403, are about one-third the diameter of the osseous tubes in which they are lodged; but in number, direction, and general form they so closely resemble the bony canals, that a separate description is thus far unnecessary. The membranous canals, which are hollow, open into the sinus communis by four single orifices, and one which is common to two canals. They are filled with the same fluid (endolymph). The ampullæ are thicker and less translucent than the rest of these tubes, and nearly fill their bony cases. That part of each ampulla which faces the concavity of the corresponding osseous semicircular canal is free, rounded and prominent externally, and smooth on the inner surface; whilst the opposite portion is flattened, receives branches of nerves and blood-vessels, and, when opened, presents on its inner surface a transverse projection (*septum transversum*), which partially divides the cavity into two.

The structure of the walls of the common sinus, sacculus, and membranous semicircular canals presents many points of resemblance. The membrane of which they are formed is generally thin and semitransparent; but it is thicker and more opaque where nerves and vessels enter. On the outer surface is a layer of minutely ramified blood-vessels and loose cellular tissue, which sometimes contains irregular deposits of pigment-cells. Next to this vascular network, branches of the auditory nerve are distributed in the form of a distinct layer, within which is fine cellular tissue, with, according to Huschke, a film of closely set nucleated epithelium-cells. It is doubtful how far the nervous layer extends into the undilated portion of the semicircular canals.

The *endolymph* (aqua labyrinthi membranacei, vel humor vitreus auris) is a thin, limpid fluid, contained in the sacculus, common sinus, and semicircular canals, and is immediately in contact with the layer of epithelium-cells lining these cavities. The endolymph contains little but water, and resembles closely the perilymph already described.

The *otolithes* (otoconies—Breschet) are two small rounded bodies, contained, the one in the common sinus, and the other in the sacculus, and composed of particles of carbonate and phosphate of lime agglutinated together by mucus and animal matter. Huschke describes the calcareous particles as distinctly crystalline, whilst Mr. Wharton Jones distinguishes them as oval and somewhat pointed granules. These bodies are slightly attached to the walls of the membranous labyrinth opposite the points of entrance of the nerves into the common sinus and sacculus, but otherwise they float freely in the endolymph.

c. The *membranous structure of the cochlea* is very different in its constitution from the rest of the membranous labyrinth, to which it is analogous only in affording a surface on which the auditory nerve divides, in order to be exposed to undulations of the fluid of the internal ear. The cochlea is entirely filled with perilymph; and the nervo-membranous structure which constitutes its sentient portion is flat, and arranged in a spiral form, so as to assist, with the osseous lamina, in separating the two scalæ. The *lamina spiralis membranacea* stretches across from the free margin of the osseous lamina to the outer circumference of the spiral canal. In the first turn of the cochlea it forms about one-third of the breadth of the septum between

the scalæ; but towards the apex of the cochlea the proportion between the two parts of the lamina is gradually reversed, until, near the helicotrema, the membranous parts of the lamina are left unsupported by any plate of bone.

In the first and second turn of the cochlea the membranous spiral lamina contains, close around the margin of the osseous plate, some cartilaginous tissue, together with particles of bone. This has given occasion to Breschet to distinguish the *zonula cartilaginea* and the *zonula membranacea;* the former ending, like the osseous lamina, in a hook-like turn (*hamulus cartilagineus*); and the latter expanding at its termination, as just described, and forming the most transparent and delicate part of the septum. Within the membranous lamina spiralis is a flattened expansion of the cochlear branch of the auditory nerve, covered on the upper surface by the membrane lining the scala vestibuli, and on the lower surface by the membrane of the scala tympani, fig. 405. Between the nervous filaments, which will be presently described, are numerous scattered opaque and osseous granules.

3. VESSELS OF THE LABYRINTH.

a. Arteries.—The *internal auditory artery,* a branch from the basilar, enters, together with the auditory and facial nerves, the internal meatus of the ear, and at the bottom of that shallow canal divides into vestibular and cochlear branches. The *vestibular* branches are distributed to the common sinus, sacculus, and semicircular canals, with the branches of nerve which they accompany through the bony foramina. The *cochlear* branches, fig. 405, twelve or fourteen in number, traverse the many small canals in the modiolus and bony lamina spiralis, and are distributed in the form of a fine network on the membrane lining the two scalæ. Of the two, the membrane of the scala vestibuli is said to be the more vascular. Besides the foregoing, which is the chief artery of the internal ear, the *stylo-mastoid* branch of the posterior auricular, and occasionally the occipital artery (Jones), send twigs to the vestibule and the posterior semicircular canal.

b. Veins.—The veins of the *cochlea* principally converge towards a small spiral sinus which is contained between the layers of the membranous lamina spiralis, close to its peripheral attachment. The veins of the *vestibule* and semicircular canals accompany the arterial branches, and, joining the circular sinus of the cochlea at the base of the modiolus, pour their contents into the superior petrosal sinus.

4. THE AUDITORY NERVE.

The special nerve of the sense of hearing (*portio mollis paris septimi, nervus auditorius*) is the only nerve distributed to the labyrinth, or internal ear. Its course from the brain to the end of the internal auditory meatus, and its connexion with the facial nerve whilst in that canal, have been described. At the bottom of the meatus the auditory nerve comes in contact with a perforated plate of bone, which assists in bounding the cavities of the vestibule and cochlea; and through the perforations in this bone the filaments of the nerve,

minutely divided, pass to their destination in the internal ear. Before entering the foramina, the auditory nerve divides into an anterior and a posterior branch (*cochlear* and *vestibular nerves*); but there is some difference of opinion amongst anatomists as to the usual precise distribution of these two primary branches. Having traversed the shell of bone, and entered the cavity of the osseous labyrinth, the filaments are grouped into fasciculi, which correspond in number with the several parts of the membranous labyrinth to which they are given. There are six of these fasciculi,—the common sinus, the sacculus, the three ampullæ of the semicircular canals, and the cochlea, receiving one each.

[Fig. 403.

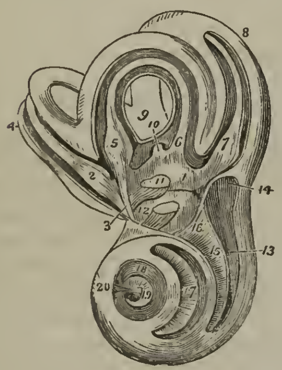


Fig. 404.

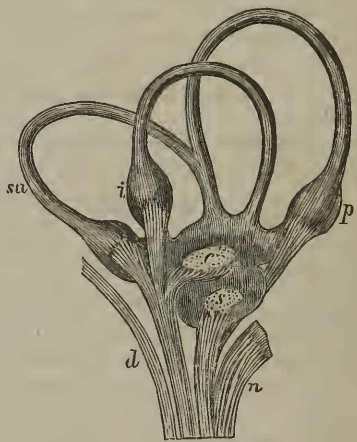


Fig. 403. The labyrinth of the left ear, laid open, in order to show its cavities and the membranous labyrinth. After Breschet. 1. The cavity of the vestibule, opened from its anterior aspect in order to show the three-cornered form of its interior, and the membranous labyrinth which it contains. The figure rests upon the common saccule of the membranous labyrinth,—the sinus communis. 2. The ampulla of the superior or perpendicular semicircular canal (4), receiving a branch of the vestibular nerve, 3. 5. The ampulla of the inferior or horizontal semicircular canal, receiving a nervous fasciculus from the superior branch of the vestibular nerve. 6. The termination of the membranous canal of the horizontal semicircular canal in the sinus communis. 7. The ampulla of the posterior semicircular canal (8), receiving a branch of the vestibular nerve. 9. The common canal, resulting from the union of the perpendicular with the posterior semicircular canal. 10. The membranous common canal terminating in the sinus communis. 11. The otoconite of the sinus communis seen through the membranous parietes of that sac. 12. The sacculus; its otoconite is seen through its membranous parietes. 13. The scala tympani. 14. The extremity of the scala tympani corresponding with the fenestra rotunda. 15. The lamina spiralis; the figure is situated in the scala vestibuli. 16. The opening of the scala vestibuli into the vestibule. 17. The second turn of the cochlea. 18. The remaining half turn of the cochlea; 19. The lamina spiralis terminating in its falciform extremity. The dark space included within the falciform curve of the extremity of the lamina spiralis is the helicotrema. 20. The infundibulum.—W.

Fig. 404. Membranous labyrinth of the left side, with its nerves and otoliths: *su.* Superior semicircular canal, with the ampulla and its nerve at one end, and the other end joined by *p*, the posterior canal, to form the common canal. *i.* Inferior, or horizontal canal, with the ampulla and its nerve at one end, and the other entering the utriculus separately. *c.* Powdery otolith seen through the translucent wall of the common sinus, or utriculus, with the nerves distributed to it. *s.* Powdery otolith of the sacculus seen with its nerve, in a similar way. *n.* Cochlear division of the auditory nerve cut off where it enters the cochlea. *d. Portio dura* of the seventh pair leaving the auditory nerve, or *portio mollis*, to enter the aqueduct of Fallopius. Magnified. From Breschet.—T. & B.]

Primary Division of the Nerve.—The nerves for the supply of the *common sinus*, and of the *superior* and the *external semicircular canals*, pass through a cluster of foramina in the upper and back part of the perforated plate of bone at the bottom of the meatus, close behind the aperture of the aqueductus Fallopii, and enter the cavity of the vestibule along the ridge (crista vestibuli), between the hemielliptical and hemispherical depressions. The filaments then unite into a common trunk, fig. 404, which afterwards sends one branch to the common sinus, a second to the ampulla of the external, and a third to the ampulla of the superior semicircular canal. The fibrils for the *sacculus* enter the vestibule by a smaller group of foramina, which are situate below those just described, and open at the bottom of the fovea hemispherica. The nerve of the *posterior semicircular canal* is a long slender branch which traverses a small passage in the bone behind the foramina for the nerve of the sacculus. It enters the flattened side of the ampulla.

Fig. 405.

Fig. 406.

Fig. 405. Section of the cochlea (from Arnold), showing the mode of distribution of some of the nerves and the artery of the internal ear—1. Auditory nerve. 2. Nerves in the lamina spiralis. 3. Central nerve of the cochlea. 4. Nerve of the vestibule. 5. Internal auditory artery.

Fig. 406. The ampullæ of the superior and external semicircular canals and part of the common sinus, showing the arrangement of the nerves. (From Steifensand.)—1. Ampulla of superior, and 2, ampulla of external semicircular canals. 3. Common sinus. 4 and 5. Fork-like swellings of the nerves to the ampullæ. 6. Radiating end of the nerve to the common sinus.

The nerve of the *cochlea*, fig. 404, *n*, and fig. 405, is shorter, flatter, and broader than any of the other nerves of the internal ear, and perforates the bone by a number of foramina at the bottom of the internal meatus, below the opening of the Fallopian aqueduct. These foramina are arranged in a shallow spiral groove (*tractus spiralis foraminulentus*), which corresponds with the coils of the canal of the cochlea; and they lead into little bony canals, which follow first the direction of the axis of the cochlea, through the modiolus, and then pass at right angles to the axis, between the plates of the bony lamina spiralis. In the centre of the spiral groove above noticed is a larger foramen, which leads to the canalis centralis modioli. Through the central foramen and straight canal the filaments for the last half-turn of the lamina spiralis and canal of the cochlea are conducted, fig. 405,[3] whilst the first two turns are supplied by filaments,[2] which occupy the smaller foramina and bent canals.

—The greater number of anatomists (including Sœmmerring, Arnold, Cruveilhier) describe the cochlear nerve as the anterior division of the portio mollis. According to Breschet,* however, the auditory nerve is divided into two branches, one of which (nerf auditif antérieur) supplies the common sinus and ampullæ of

the anterior and the external semicircular canals, whilst the other (nerf auditif postérieur) sends off the cochlear nerve, and the nerves of the sacculus and posterior semicircular canal.

Ultimate Distribution of the Branches of the Auditory Nerve.—In the membranous vestibule and semicircular canals, the nervous filaments, deprived of the thicker sheath which covered them whilst in the auditory meatus, are invested in a thin prolongation of the membranous labyrinth itself (Breschet), this being always thicker at the points at which the nerves enter. The nerves of the *common sinus* and *saccule* terminate nearly in the same manner. They perforate the membrane somewhat obliquely, and forming a slight projection on the inner surface of the sacs, divide at once into a fine pulpy network analogous to the retina of the eye. The network is composed of radiating lines of nervous globules deprived of their neurilemma and supported on a fine vascular membrane; it is in close contact with the otolithes, and is separated from the endolymph only by a layer of epithelium-cells.

The nerves of the *semicircular canals* enter the flattened or least prominent side of the ampullæ, where they each form a forked swelling, fig. 406, which corresponds with the transverse septum already described in the interior of the dilatation. From the forked swelling a pulpy nervous layer, deprived of neurilemma, extends into the transverse septum and over the inner surface of the walls of the ampulla; but it is yet undetermined how far the nerve extends into the undilated portion of the semicircular canals.

The nerve of the *cochlea*, as it passes through the modiolus and osseous lamina spiralis, divides into minute cylindrical branches, which, on entering the middle or cartilaginous zone become very indistinct, and are mixed up with granules and particles of osseous matter. The precise mode of their ultimate distribution is still uncertain. By Scarpa they were said to form brushes, and by Sœmmerring a feather-like arrangement, of filaments. By Treviranus they were thought to end in papillæ; and according to Breschet they become flattened, anastomose together, and terminate in loops which are surrounded by irregularly scattered granules.

THE NOSE.

THE nose is the special organ of the sense of smell; but it has other functions to fulfil,—for, communicating freely with the cavities of the mouth and lungs, it is concerned in respiration, voice, and taste; and, by means of muscles on its exterior, which are closely connected with the muscles of the face, it assists in the expression of the different passions and feelings of the mind.

This organ consists of, first, the anterior prominent part, composed of bone and cartilage, with muscles which slightly move the latter, and two orifices (*anterior nares*) opening downwards; and, secondly, of the two nasal fossæ, in which the olfactory nerves are expanded. The narrow cavities last mentioned are separated one from the other by a partition (*septum narium*) formed of bone and cartilage: they communicate at the outer side with hollows in the neighbouring bones (ethmoid, sphenoid, frontal, and superior maxillary); and they open backwards into the pharynx through the posterior nares. The parts here indicated in connexion will now be noticed in detail.

* Recherches anatomiques et physiologiques sur l'Organe de l'Ouie, &c. Paris, 1836.

1. BONES OF THE NOSE.

The outer projecting part of the nose is supported in part by the nasal bones, and the nasal processes of the superior maxillary bones, forming the bridge of the nose. The large triangular opening left between those bones has been described (at vol. i. p. 157), and the bones which inclose the cavity of the nose have also been described (ante, vol. i. p. 161).

2. CARTILAGES OF THE NOSE.

These are the chief support of the outer part of the organ. They occupy the triangular opening seen in front of the nasal cavity in the dried skull, and assist in forming the septum between the nasal fossæ. There are two larger, and three smaller cartilages on each side, and one central piece or cartilage of the septum.

The *upper lateral cartilages* (cartilagines laterales nasi), fig. 407,[1] and 408, *b*, are situate in the upper part of the projecting portion of the

Fig. 407.

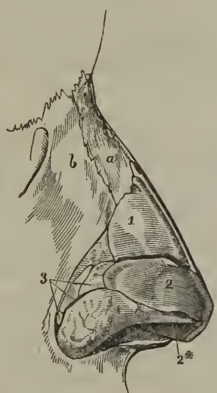


Fig. 408.

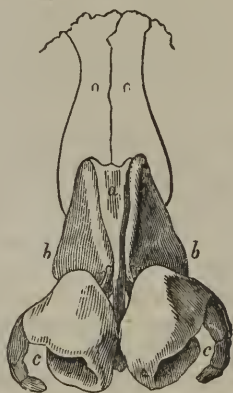


Fig. 407. View of the bones and cartilages of the outer nose, from the right side. (Arnold.)—*a*. Nasal bone. *b*. Nasal process of upper maxillary bone. 1. Right upper lateral cartilage. 2. Lower lateral cartilage, its outer part. 2*. Inner part of the same. 3. Sesamoid cartilages.

Fig. 408. Front view of the cartilages of the nose. Above is seen the outline of the nasal bones.—*a*. Front edge of the septal cartilage. *b*, *b*. Lateral cartilages. *c*, *c*. Alar cartilages, with their appendages.—After Sœmmerring.

nose, immediately below the free margin of the nasal bones. Each cartilage is flattened and triangular in shape, and presents one surface outwards, and the other inwards towards the nasal cavity. The anterior margin, thicker than the posterior one, does not quite meet the lateral cartilage of the opposite side, but is closely united with the edge of the cartilage of the septum; the lower margin is connected by fibrous membrane with the lower lateral cartilage; and the posterior edge is inserted into the ascending process of the upper maxilla, and the free margin of the nasal bone.

The *lower lateral cartilages* (cartilagines alarum nasi), fig. 407, and 409,[2] are thinner than the preceding, below which they are placed, and

are chiefly characterized by the curve which they form. Each cartilage consists of an elongated plate, so bent upon itself as to pass at

Fig. 409.

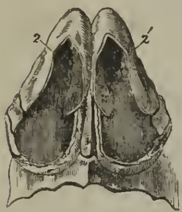


Fig. 410.

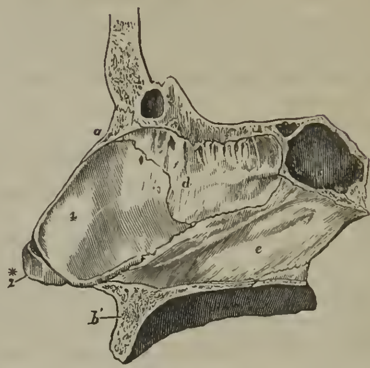


Fig. 409. View of the cartilages of the nose, looking into the nostrils from below. (From Arnold.)—2. Outer part of the lower lateral cartilages. 2*. Inner part of the same. 4. Lower edge of the cartilages of the septum.

Fig. 410. Osseous and cartilaginous septum of the nose, seen from the left side. (After Arnold.)—*a*. Nasal bone. *b*. Superior maxillary bone. *c*. Sphenoidal sinus. *d*. Central or perpendicular plate of the ethmoid bone. *e*. Vomer. 2*. Inner part of the (right) lower lateral cartilage of the nose. 4. Cartilage of the septum.

each side of the orifice of the nose, and, by this arrangement, serving to keep it open. One portion supports and gives form to the upper part of the ala; and the other projects backwards, and bounds the nostril on the inner side. The *outer portion* is somewhat oval and flattened, or irregularly convex externally. Behind, it is attached to the margin of the ascending process of the upper maxilla, by tough fibrous membrane, in which are two or three cartilaginous nodules (*cartilag. minores vel sesamoideæ*); above, it is fixed, also, by fibrous membrane, to the upper lateral cartilage, and to the lower and fore part of the cartilage of the septum; towards the middle line it leaves a deep groove, at the bottom of which it adheres to the opposite cartilage. The *inner portion* of the lower lateral cartilage,[2*] forms a small part of the columna nasi, where it projects below the anterior angle of the cartilage of the septum. This part of the cartilage of the ala is thicker than the rest of the structure, curls outwards, and ends in a free rounded margin, which projects outwards towards the nostrils, fig. 409,[2*]. The lower and most prominent portion of the ala of the nose, like the lobule of the ear, is formed of cellular tissue, unsupported by cartilage, and covered by skin.

The *cartilage of the septum* (cartilago septi narium), fig. 409,[4] and 410,[4] has a somewhat triangular outline, and is thicker at the edges than near the centre. It is placed nearly vertically in the middle line of the nose, and completes, at the fore part, the separation between the nasal fossæ. The anterior margin of the cartilage, thickest above, is firmly attached to the back of the nasal bones near their line of junction,[a]; and below this it lies between, and is united with, the fore

part of the upper lateral, and the inner portions of the lower lateral cartilages. The posterior margin is fixed to the lower and fore part of the central plate of the ethmoid bone,[d1]; and the lower margin is received into a groove in the upper or anterior edge of the vomer.*

3. THE MUSCLES OF THE NOSE.

These are described with the muscles of the face, with which they are associated in position, attachments, and function. They are the pyramidalis nasi, the levator labii superioris alæque nasi, the compressor naris, the depressor alæ nasi, and the levatores proprii alæ nasi (anterior et posterior). (See vol. i. p. 337.)

4. THE SKIN.

Over the upper part and sides of the nose, the skin is thin and loosely connected with the bones and cartilages on which it lies. Over the lower lateral cartilages, it gradually becomes firmer and more adherent; and in the free part of the alæ, where it has no extra support, it is thick and solid. It is here closely adherent to the muscles, and incloses small, separate, hard granules of fat. At the free margin of the ala the skin is folded on itself, and incloses, with the inner part of the lower lateral cartilage, and lower part of the septum nasi, an oval aperture on each side (*naris*, *apertura nasi externa*), which leads into the corresponding nasal fossæ. The skin of the nose is studded, particularly in the grooves of the alæ, with numerous small openings, which lead to sebaceous follicles. Within the margin of the nostrils, there are several short, stiff, and slightly curved hairs (*vibrissæ*), which grow from the inner surface of the alæ and septum nasi, up to the point at which the skin is continuous with the mucous membrane lining the cavity of the nose.

NASAL FOSSÆ.

The nasal fossæ, and the various openings into them, with the posterior nares, have been described as they exist in the skeleton (see ante, vol. i. p. 161), and that description is also generally applicable to the nose in a recent state; but there are certain differences in the form and dimension of parts, which, as they depend on the arrangement of the lining membrane, will be noticed after the general account to be given of that membrane.

5. PITUITARY OR SCHNEIDERIAN MEMBRANE.

The cavities of the nose are lined by a mucous membrane of peculiar structure, which like the membrane that lines the cavity of the tympanum, is almost inseparably united with the periosteum and perichondrium, over which it lies; it belongs, therefore, to the class of fibro-mucous membranes, and it is highly vascular. Named the pituitary membrane, it is continuous with the skin, through the anterior openings of the nose; with the mucous membrane of the pharynx,

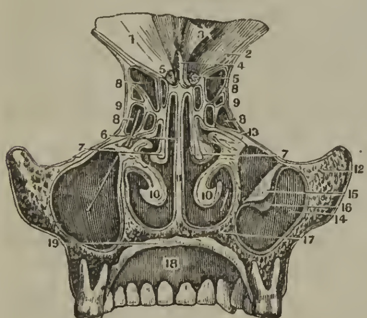
* M. Cruveilhier describes a thin band of this cartilage ("prolongement caudal") which extends backwards and upwards in the groove of the vomer, to be attached to the rostrum of the sphenoid bone. (Anatomie Descriptive, 1834, vol. iii. p. 429.)

through the posterior apertures of the nasal fossæ; with the conjunctiva, through the nasal duct and lachrymal canaliculi; and with the lining membrane of the several sinuses which communicate with the nasal fossæ. The pituitary membrane, however, varies much in thickness, vascularity, and general appearance in these different parts. It is thickest and most vascular over the turbinate bones (particularly the inferior), from the most dependent parts of which it forms, in front and behind, projections, which increase the surface, and make the turbinate bones appear, in the recent state, longer and more prominent than they are in the skeleton. On the septum narium, the pituitary membrane is still very thick and spongy; but in the intervals between the turbinate bones, and over the floor of the nasal fossæ, it is considerably thinner.

The mucous lining membrane of the antrum of Highmore, of the frontal sinuses, and of the ethmoidal and sphenoidal cells, contrasts strongly with that which occupies the nasal fossæ, being very thin and pale, and wearing the appearance more of a serous than of a mucous membrane.

The lining membrane of the nose is defended by a layer of epithelium, which, in the fore part of the cavity is laminated; but which in the rest of the nasal fossæ, and in the cavities which communicate with them, is covered with vibratile cilia. This membrane likewise contains a nearly continuous layer of mucous glands, the orifices of which are apparent on the surface, fig. 412. The glands are most numerous about the middle and fore part of the nasal fossæ, and are largest at the back of the septum, near the floor of the nasal cavity. They are much smaller and less numerous in the membrane lining the several cavities, already mentioned, which communicate with the nasal fossæ. The vessels and nerves which ramify in the pituitary membrane will be presently described.

[Fig. 411.



A vertical section of the middle part of the nasal fossæ, giving a posterior view of the arrangement of the ethmoidal cells, &c. 1. Anterior fossæ of the cranium. 2. The same covered by the dura mater. 3. The dura mater turned up. 4. The crista galli of the ethmoid bone. 5. Its cribriform plate. 6. Its nasal lamella. 7. The middle spongy bones. 8. The ethmoidal cells. 9. The os planum. 10. Inferior spongy bone. 11. The vomer. 12. Superior maxillary bone. 13. Its union with the ethmoid. 14. Anterior parietes of the antrum highmorianum, covered by its membrane. 15. Its fibrous layer. 16. Its mucous membrane. 17. Palatine process of the superior maxillary bone. 18. Roof of the mouth covered by the mucous membrane. 19. Section of this membrane. A bristle is seen in the orifice of the antrum highmorianum.—S. & H.]

The effect of the pituitary membrane on the form and dimensions of the nasal fossæ, before mentioned, as causing the difference which exists between those cavities in the skeleton and in the recent state, will now be further adverted to.

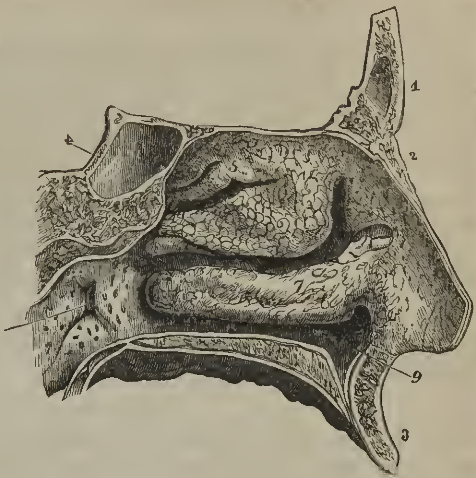
First: owing to the thickness of the membrane in question, (which not only lines the walls of the fossæ, but covers the spongy bones on both sides,) the nasal cavity is much narrower in the recent state. (See fig. 411.) Secondly, in consequence of the prolongations of membrane already alluded to, on the free margins of the turbinate bones, these bones, and more particularly the lower pair, appear in the recent state to be more prominent and longer in the direction from before backwards, than in the dried skull. Thirdly, by the arrangement of the mucous membrane round the orifices

which open into the nasal fossæ, some of the foramina in the bones are narrowed or completely closed.

In the *upper meatus*, the small orifices which lead into the posterior ethmoidal cells, and through them into the sphenoidal sinuses, are merely lined by a prolongation of the thin mucous membrane which continues into these cavities; but the spheno-palatine foramen (of the dried bones) is covered over by the Schneiderian membrane, so that no such opening exists in the recent nasal fossæ.

In the *middle meatus*, the aperture of the infundibulum, nearly hidden by an overhanging fold of membrane, leads directly into the anterior ethmoidal cells, and through them into the frontal sinus. Below and behind this, the passage into the antrum of Highmore is surrounded by a circular fold of the pituitary membrane, (sometimes prominent and even slightly valvular,) which leaves a nearly circular aperture much smaller than the foramen in the bony meatus.

Fig. 412.



The outer wall of the left nasal fossa covered with the pituitary membrane. 1. Frontal bone. 2. Nasal bone. 3. Superior maxillary. 4. Sphenoid. 5. The upper spongy bone. 6. Middle spongy bone. 7. Lower spongy bone. The three meatuses of the nose are seen below the three last-named bones. 8. The opening of the Eustachian tube.

In the *lower meatus*, the inferior orifice of the nasal duct is defended by two nearly vertical folds of membrane, between which is a narrow slit; and the folds are often adapted so accurately together as to prevent even air from passing back from the cavity of the nose to the nasal sac. The anterior palatine foramina (described at p. 140, vol. i.), are in the recent state generally closed by the Schneiderian membrane. Sometimes, however, a narrow funnel-shaped tube of mucous membrane descends for a little distance into the canals, but is closed before it reaches the roof of the palate.* Lastly, the apertures in the cribriform plate of the ethmoid bone are likewise covered over by membrane.

6. THE BLOOD-VESSELS OF THE NOSE.

The nose receives numerous branches from the facial, internal maxillary, and ophthalmic arteries, which anastomose very freely with each other. Its veins join the facial and ophthalmic trunks.

Arteries.—On the outer surface of the nose, the alæ and columna nasi are supplied by the coronary artery of the upper lip and the lateral nasal,—both branches of the facial artery (see vol. i. p. 544). The sides and upper part of the nose receive branches from the lateral nasal (just mentioned), the nasal branch of the ophthalmic artery, which emerges above the tendo tarsi (p. 554), and from the infraorbital artery. The ethmoidal cells, frontal sinuses, and roof of the nasal cavity receive their blood from the anterior and posterior ethmoidal branches of the ophthalmic

* Vesalius, Stenson, and Santorini believed that the tube of membrane, above alluded to, opens generally into the roof of the mouth by a little aperture close behind the interval between the central incisor teeth. Haller, Scarpa, and more recently, Jacobson, find that in man it is usually closed, and often difficult of detection. (See Cuvier's Report on a paper by Jacobson. "Annales du Muséum d'Hist. Naturelle;" Paris, 1811; vol. xviii., p. 412.)

artery. The vascular membrane over the spongy bones and meatus of the nose derives its chief supply from the spheno-palatine branches of the internal maxillary artery; and the alveolar artery, from the same trunk, sends twigs into the antrum of Highmore. The chief artery of the septum springs also from the spheno-palatine, and anastomoses in the anterior palatine canal with the terminal branch of the descending palatine artery, which runs from the soft palate into the nose.

Veins.—From the outer surface of the nose the blood is returned principally by radicles of the facial vein. Within the cavity of the organ, the veins, which are very much larger than the arteries, form a plexus between the mucous and fibrous layers of the pituitary membrane, particularly over the spongy bones and the septum. Some of the largest of these vessels make their exit through the spheno-palatine foramen, and, by means of the alveolar branch, join the facial vein. Others, from the roof of the nasal fossæ, ethmoidal cells and frontal sinuses (ethmoidal veins), enter the orbit, and join the ophthalmic vein. The veins of the nose communicate freely with the veins within the cavity of the skull through the foramina in the cribriform plate of the ethmoid bone.

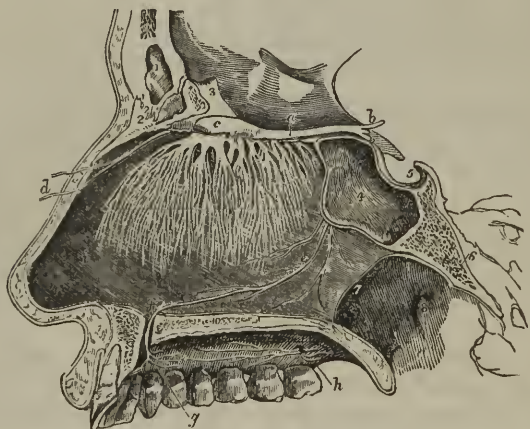
7. THE NERVES OF THE NOSE.

The nerves of the nose, like the vessels, are numerous; the largest and most important being that which endows it with the power of receiving the impressions of smell.

OLFACTORY NERVE.

The origin of this nerve, the passage of its branches through the cribriform plate of the ethmoid bone, and the arrangement of these

[Fig. 413.



The olfactory nerve, with its distribution on the septum nasi. The nares have been divided by a longitudinal section made immediately to the left of the septum, the right nares being preserved entire. 1. The frontal sinus. 2. The nasal bone. 3. The crista galli process of the ethmoid bone. 4. The sphenoidal sinus of the left side. 5. The sella turcica. 6. The basilar process of the sphenoid and occipital bones. 7. The posterior opening of the right nares. 8. The opening of the Eustachian tube in the upper part of the pharynx. 9. The soft palate, divided through its middle. 10. Cut surface of the hard palate. *a.* The olfactory peduncle. *b.* Its three roots of origin. *c.* Olfactory ganglion, from which the filaments proceed that spread out in the substance of the pituitary membrane. *d.* The nasal nerve, a branch of the ophthalmic nerve, descending into the left nares from the anterior foramen of the cribriform plate, and dividing into its external and internal branch. *e.* The naso-palatine nerve, a branch of the spheno-palatine ganglion distributing twigs to the mucous membrane of the septum nasi in its course to (*f*) the anterior palatine foramen, where it forms a small gangliform swelling (Cloquet's ganglion) by its union with its fellow of the opposite side. *g.* Branches of the naso-palatine nerve to the palate. *h.* Posterior palatine nerves. *i, i.* The septum nasi.—C.]

branches after they enter, and begin to divide in the cavity of the nose, have been already described (ante, pp. 243 and 260). The general distribution of the outer and inner set of branches is nearly similar. At first, lodged in grooves on the surface of the bone, the nerves enter obliquely the substance of the Schneiderian membrane, so as to get between the mucous and fibrous layers. Here they soon divide into brush-like and flattened tufts of filaments, which, spreading out laterally, and communicating freely with similar branches on either side, form a fine and close network, with long and narrow intervals between the points of junction. Whilst thus dividing, the nerves are enveloped in sheaths of dura mater, prolonged from the foramina in the ethmoid bone, which makes them much firmer than where they are connected with the olfactory bulb. The nerves of the septum, fig. 413, are rather larger than those of the outer wall of the nasal fossæ; as they descend, they become very indistinct, and are not visible on the lower fourth of the septum. The nerves of the outer wall, fig. 355, are divided into two groups;—the posterior branches are distributed over the surface of the upper spongy bone, and the anterior branches descend over the middle spongy bone, but are then too small to be traced even round the free margin of this bone. No branch of the olfactory nerve has been found in the mucous membrane over the lower spongy bones, or the middle and lower meatus.

The smaller nerves of the nose have been already fully described, and will, therefore, here be merely enumerated and referred to. On the outer surface of the nose are distributed branches of the facial and infra-orbital nerves (p. 269), the infratrochlear nerve, and a twig of the nasal branch of the ophthalmic (p. 266). To the upper and anterior part of the septum and outer wall of the nasal fossæ are given other branches of the nasal division of the ophthalmic nerve. To the upper and back part of the septum, and to the upper spongy bones, are distributed nerves derived from the Vidian nerve (p. 272), and from the spheno-palatine ganglion (p. 272). The middle of the septum receives the naso-palatine nerve (fig. 413), as it courses to the anterior palatine foramen. The middle and lower spongy bones are supplied by offsets from the larger palatine branch of the spheno-palatine ganglion (fig. 355); and lastly, the lower meatus and the lower spongy bone are further furnished with little twigs from the anterior dental nerve, a branch of the upper maxillary (p. 269).

ORGANS OF DIGESTION.

The *digestive apparatus* includes that portion of the organs of assimilation within which the food is received and partially converted into chyle, and from which, after the chyle has been absorbed, the residue or excrement is expelled. It consists of a main or primary part named the *alimentary canal*, and of certain *accessory organs.*

The alimentary canal is a long membranous tube, commencing at the mouth and terminating at the anus, composed of certain tunics or coats, and lined by a continuous mucous membrane from one end to the other. Its average length is about thirty feet, being about five or six times the length of the body. The upper part of it is placed beneath the base of the skull, the succeeding portion is situated within the thorax, and the remainder is contained within the cavity of the abdomen. In these several situations, its form, dimensions, and connexions, its structure and its functions, are so modified, that certain natural subdivisions of it, bearing different names, have been recognised by all anatomists.

It may be considered as composed of two parts: one situated above the diaphragm, and the other below that muscular partition, and therefore within the abdomen. The first division consists of the organs of mastication, insalivation, and deglutition; and comprises the *mouth*, the *pharynx*, and the *œsophagus* or gullet. The second division consists of the organs of digestion properly so called, and of those of defæcation: viz., the *stomach*, the *small intestine*, and the *great intestine.*

The accessory parts are chiefly glandular organs, which pour their secretions into it at different points. They consist of the *salivary glands* (named the *parotid*, *submaxillary*, and *sublingual*), the *liver*, and *pancreas.* Besides these large glandular organs, a multitude of small glands, compound, follicular or tubular, are collected together at certain points, or scattered over large portions of the inner surface of the alimentary canal: these will be described with the mucous membrane of each part. The remaining accessory organs are the *teeth*, the *jaws*, the *tongue*, and the *spleen.*

THE MOUTH.

The *mouth* (fig. 444) is the space included between the lips and the throat or fauces. It is bounded in front by the lips, *d d*, at each side by the cheeks, below by the tongue, *b*, and above by the hard and soft palate, *a* and *c*; whilst behind it communicates with the pharynx at 3, through an opening called the *fauces* (isthmus faucium). The cavity of the mouth, with its contained parts (excepting, of course, the teeth), is lined throughout by a mucous membrane, which is of a

pink rosy hue during life, but pale gray after death, and which presents peculiarities of surface and structure to be noticed hereafter.

The *lips*, which bound the anterior aperture or *rima* of the mouth, are composed of an external layer of skin, and of an internal layer of mucous membrane; between which are found, besides muscles, vessels and nerves, already fully described in other parts of this work, some cellular tissue, fat, and numerous small glands. The principal muscle is the orbicularis oris; but several others are inserted into this one at various points, and enter more or less into the formation of the lips. The free border of the lips is protected by a dry mucous membrane, which becomes continuous with the skin, is covered with numerous minute papillæ, and is highly sensitive. On the inner surface of each lip, the mucous membrane forms a fold in the middle line, connecting the lip with the gums of the corresponding jaw. These are the *fræna* or *frænula* of the lips: that of the upper lip is much the larger of the two.

Numerous small glands, called *labial glands*, are found beneath the mucous membrane of the lips, around the opening of the mouth. They are situated between the mucous membrane and the orbicularis oris muscle. They are compound glands of a rounded form, the largest of them not exceeding the size of a split pea; and they open into the mouth by distinct orifices.

The *cheeks*, like the lips, consist of a cutaneous, a muscular, and a mucous layer, besides fat, cellular tissue, glands, vessels, and nerves. The principal muscle of the cheek is the buccinator, but the two zygomatici, the masseter, the orbicularis palpebrarum, and the platysma in part enter into its formation. There is a remarkable accumulation of fat between the masseter and buccinator muscles. Between the last-named muscle and the mucous membrane are the *buccal* glands, similar to the labial glands, but smaller. Two or three glands, larger than the rest, found between the masseter and buccinator muscles, and opening by separate ducts near the last molar tooth, are called the *molar* glands.

The duct of the parotid gland also opens upon the inner surface of the cheek, opposite to the second upper molar tooth.

Immediately behind the lips and cheek, are the *dental arches*, consisting of the teeth, gums, and maxillæ. The jaw-bones, the articulation and movements of the lower maxilla, and the muscles used in mastication, are elsewhere described. The *gums* (gingivæ), which scarcely require a notice, are composed of a dense fibrous tissue, connected very closely with the periosteum of the alveolar processes, and covered by a red and not very sensitive mucous membrane, which is smooth in its general surface, but immediately around the teeth is beset with fine papillæ.

THE TEETH.

In the human subject, as in mammalia generally, two sets of teeth make their appearance in the course of life, of which the first constitutes the *temporary*, *deciduous*, or *milk* teeth, whilst the second is named the *permanent* set. The temporary teeth are twenty in num-

ber, ten in each jaw, and the permanent set consists of thirty-two, sixteen above and sixteen below. Deficiencies in the number of the teeth sometimes occur, but much more frequently the number is increased by one or more supernumerary teeth. These are usually small, and provided with only a single fang; and, though generally distinct, they are sometimes attached to other teeth: they occur more frequently near the front than the hinder teeth, and are more often met with in the upper than in the lower jaw.

General Characters of the Teeth.—Though the teeth are distinguished by peculiarities of external configuration into several classes, they have all certain characters in common. Thus, each tooth is described as consisting of three portions, viz., one which projects above the gums and is named the body or *crown*,—another which is lodged in the alveolus or socket, and constitutes the root or *fang*,—and a third, intermediate between the other two, and from being more or less constricted, named the cervix or *neck*. The size and form of each of these parts vary in the different kinds of teeth.

The roots of all the teeth are implanted into the alveoli of the jaws, and are accurately fitted to them, by a peculiar mode of union, called gomphosis (γομφος, a nail). Each alveolus is lined by the periosteum, which is also reflected on to the contained fang, and invests it as high as the cervix. This dental periosteum, sometimes named the periodontal membrane, is blended with the dense and slightly sensitive tissue of the gums, which closely surrounds the neck of the tooth. The roots of all the teeth taper from the cervix to the point, and this form, together with the accurate adjustment to the alveolus, has the effect of distributing the pressure during use, over the whole socket, and of preventing its undue action on the apex of the fang, through which the blood-vessels and nerves enter.

The thirty-two permanent teeth consist of four incisors, two canines, four bicuspids, and six molars, in each jaw. The twenty temporary teeth are four incisors, two canines, and four molars, above and below. There are no bicuspids among the temporary teeth, but the eight deciduous molars are succeeded by the eight bicuspids of the permanent set. The relative position and arrangement of the different kinds of teeth in the jaws may be shown by the following scheme, which also exhibits the relation between the two sets in these respects:

		MO.	CA.	IN.	CA.	MO.		
Temporary teeth	Upper	2	1	4	1	2	= 10	= 20
	Lower	2	1	4	1	2	= 10	

		MO.	BI.	CA.	IN.	CA.	BI.	MO.		
Permanent teeth	Upper	3	2	1	4	1	2	3	= 16	= 32
	Lower	3	2	1	4	1	2	3	= 16	

Special Characters of the Permanent Teeth.—The *incisors*, (fig. 414, *a*, *b*,) eight in number, are the four front teeth in each jaw, and are so named from being adapted for cutting or dividing the soft substances used as food. Their *crowns* are chisel-shaped, and have a sharp horizontal cutting edge, which, by continued use, is bevelled off

behind in the upper teeth, but, in the lower teeth, is worn down in front. Before being subjected to wear, the horizontal edge of the incisor teeth is serrated or marked by three small prominent points (*d*). The anterior surface of the crown is slightly convex, and the posterior concave (*c*). The *fang* is long, single, conical, and compressed at the sides, where it sometimes though rarely presents a slight longitudinal furrow.

The lower incisor teeth are placed vertically in the jaw, but the upper teeth are directed obliquely forwards. The upper incisors are, on the whole, larger than the lower ones. In the upper jaw the central incisors are larger than the lateral, whilst the reverse is the case in the lower jaw, the central incisors being there the smaller, and being, moreover, the smallest of all the incisor teeth.

The *canine* teeth (canini, cuspidati), four in number (fig. 415), are placed one on each side, above and below, immediately next to the lateral incisors. They are larger and stronger than the incisor teeth. The *crown* is thick and conical, convex in front and hollowed behind (*b*), and may be compared to that of a large incisor tooth the angles of which have been filed away, so as to leave a single central point or *cusp* (*a*), whence the name *cuspidate* applied to these teeth. The point always becomes worn down by use. The *fang* of the canine teeth is single, conical, and compressed at the sides; it is longer than the fangs of any of the other teeth, and is so large as to cause a cor-

Fig. 414.

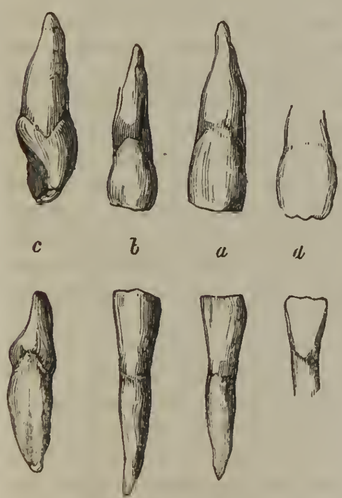


Fig. 415.

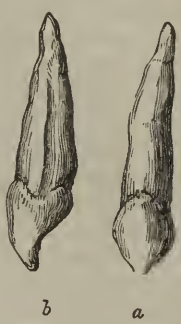


Fig. 416.

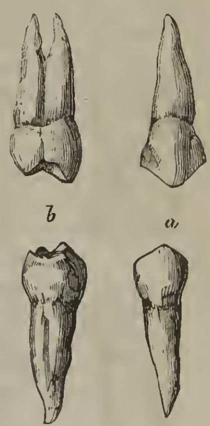


Fig. 414. Incisor teeth of the right side of the upper and lower jaws.—*a*. The middle incisors, upper and lower, seen in front. *b*. The lateral incisors, ditto. *c*. The middle incisors, seen on the side, to show the chisel-shape of the crown. The fang of the lower tooth is marked by a slight groove. *d*. Shows the indented edge of the incisors before they are subjected to wear.

Fig. 415. Canine tooth of the upper jaw, or eye-tooth.—*a*. Seen in front. *b*. Lateral view; showing the long fang grooved on the side.

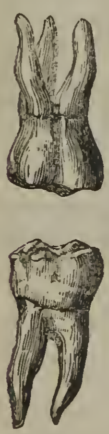
Fig. 416. Bicuspid tooth of the upper and lower jaw.—*a*. Front view. *b*. Lateral view, showing the two cusps of the crown and the groove on the side of the fang, which has become cleft in the upper tooth.

responding prominence of the alveolar arch: on the sides (*b*) it is marked by a groove, an indication, as it were, of the cleft or division which appears in the teeth next following.

The upper canines, popularly called the *eye-teeth*, are larger than the lower, and in consequence of this, as well as of the greater width of the upper range of incisors, they are thrown a little further outwards than the lower canine teeth. In the dog tribe, and in the carnivora generally, these teeth acquire a great size, and are fitted for seizing and killing prey, and for gnawing and tearing it when used as food.

The *bicuspids* (bicuspidati), (fig. 416,) also called the small, false, or premolars, are four in each jaw; they are shorter and smaller than the canines, next to which they come, two on each side. The *crown* is compressed before and behind, its long diameter being across the jaw; it is convex, not only on its outer or labial surface (*a*), like the preceding teeth, but on its inner surface also, which rises vertically from the gum (*b*); its free surface, which is therefore broader than that of an incisor or canine tooth, is surmounted by two pointed tubercles or cusps, of which the external one is larger and higher than the other. The *fang* is also flattened and is deeply grooved in all cases, showing a tendency to become double. The apex of the fang is generally bifid, and in the second upper bicuspid, the root is often cleft for a considerable distance (*b*). The upper bicuspids are larger and more characteristic in form than the lower ones. Sometimes the first lower bicuspid has only one tubercle distinctly marked, *i. e.*, the external, and in that case approaches in figure to a canine tooth.

Fig. 417.



First molar tooth of the upper and the lowerjaw. The crown of the upper molar has four cusps, and its root three fangs. The crown of the lower has five cusps, and its root two fangs.

The *molar* teeth (fig. 417), true or large molars, or multicuspid teeth, are twelve in number, and are arranged behind the bicuspid teeth, three on each side, above and below. They are distinguished by the large size of the crown, and by the great width of its grinding surface. The first molar is the largest, whilst the third is the smallest, in each range, so that in point of size a gradation is observed in these teeth. The last molar in each range, owing to its late appearance through the gums, is called the *wisdom tooth*, dens sapientiæ. The *crowns* of the molar teeth are low and cuboid in their general form. Their outer and inner surfaces are convex, whilst they are rather flattened before and behind. The grinding surface is nearly square in the lower teeth, and rhomboidal in the upper, the corners being rounded off: it is not smooth, but is provided with four or five trihedral tubercles or cusps (whence the name of multicuspidati), separated from each other by a crucial depression. The upper molars have four cusps situated at the angles of the masticating surface (see figure); of these the internal and anterior cusp is the largest, and is frequently connected with the posterior external cusp by a low oblique ridge. In the upper wisdom teeth, the two internal tubercles are blended together. The crowns of the

lower molars, which are larger than those above, have five cusps, (see figure,) the additional one being placed between the two posterior cusps, and rather to the outer side: this is especially evident in the lower wisdom teeth, in which the crown is smaller and rounder than in the others. The *fangs* of all the molar teeth are multiple. In the two anterior molars of the upper jaw, they are three in number, viz., two placed externally, which are short, divergent, and turned towards the antrum of the superior maxilla; and a third or internal fang, which is larger and longer, and is directed towards the palate. This third fang is often slightly grooved, especially when the two internal cusps are very distinct, and sometimes it is divided into two. The two anterior molars of the lower jaw have each two fangs, one anterior, the other posterior, which are broad, compressed and grooved on the faces that are turned towards each other: they have an inclination or curve backwards in the jaw, and are either slightly divergent or are nearly in contact with each other; sometimes one or both of them is divided into two smaller fangs. In the wisdom teeth of both jaws the fangs are generally connate or collected into a single irregular conical mass, which sometimes shows traces of a subdivision into two fangs in the lower teeth, and into three in the upper teeth: these connate fangs are either directed backwards in the substance of the jaw, or are curved or bent irregularly.

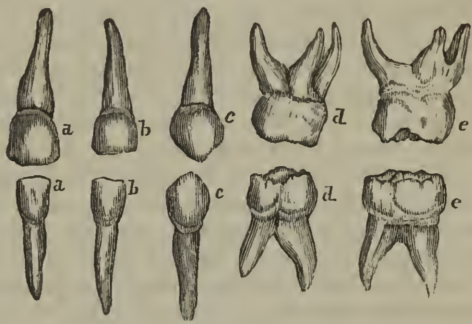
The bicuspid and the molar teeth, from the breadth of their crowns, are fitted for bruising, crushing, and grinding the food in mastication.

The entire set of teeth in each jaw forms an even curve or arch, which is not broken by any intervals, as is the case in the dental apparatus of many animals, even in the Quadrumana. The upper dental arch is rather larger than the lower one, so that the teeth of the upper jaw slightly overhang the lower set. This is owing principally to the fact that the lower teeth are placed either vertically, as in front, or are set so as to look somewhat inwards, as is seen behind and at the sides, whilst the corresponding teeth of the upper jaw have an inclination forwards in front and outwards behind. The crowns of the whole series of teeth in man are remarkably even in height, in which, however, they diminish very slightly from the incisors backwards to the wisdom teeth. In consequence of the large proportionate size of the upper central incisors, the other teeth of the upper jaw are thrown somewhat backwards, so that in closure of the jaws they come into contact partly with their corresponding lower teeth and partly with the lower teeth next following. Since, however, the upper dental arch is rather larger, and the crowns of the molars, especially the wisdom teeth, above, are smaller than those below, the dental ranges terminate behind at the same point in both jaws.

The *Milk Teeth* (fig. 418).—The forms of the different kinds of the temporary teeth resemble those of the permanent set; but they are all smaller. The temporary molar teeth (*d*, *c*) present some peculiarities. The hinder one of the two is always the larger; it is the largest of all the milk teeth, and is larger even than the second permanent bicuspid, by which it is afterwards succeeded. The *crown* of the first upper milk molar has only three cusps, two external and one internal; that

of the second has four distinct cusps. The first lower temporary molar has four cusps, and the second five, of which in the latter case three are external. The *fangs* of the temporary molars resemble those of the permanent set, but they are smaller, and are more divergent from the neck of the tooth.

[Fig. 418.



Temporary teeth. *a.* Central incisor. *b.* Lateral incisor. *c.* Canine. *d.* First molar. *e.* Second molar.—W.]

Structure.—On making a section of a tooth, the hard substance of which it is composed is found to be hollow in the centre (fig. 419). The form of the cavity bears a general resemblance to that of the tooth itself; it occupies the interior of the crown, is widest opposite to the neck, and extends like a fine canal down each fang, at the point of which it opens by a small orifice. In the crown of the incisor teeth the cavity is prolonged into two fine linear canals, which proceed one to each corner of the crown; in the bicuspid and molar teeth it advances a short distance into each cusp. In the case of a root formed by the blending of two or more fangs, as occurs occasionally in the wisdom teeth, each division has a separate canal prolonged down to its apex. The central cavity of a tooth is called the *pulp-cavity*, because it is occupied and accurately filled by a soft, highly vascular, and sensitive substance, called the *dental pulp*. This pulp consists of cellular filaments, amongst which numerous nuclei are rendered visible by the action of acetic acid. It is well supplied with vessels and nerves, which are derived from the internal maxillary artery and the fifth pair, and which enter the cavity through the small aperture at the point of each fang: according to Valentin and Hannover, the terminations of the nervous fibres are looped.

[Fig. 419.

A view of an incisor and of a molar tooth, in longitudinal section. 1. The enamel. 2. The dentine. 3. The pulp-cavity.—S. & H.]

The solid portion of the tooth is composed of three distinct substances, viz., the proper dental substance, *ivory* or *dentine*, (fig. 420,[1])

the *enamel* (4), and the *cement* or *crusta petrosa* (3). The dentine constitutes by far the larger part of the hard substance of a tooth; the enamel is found only upon the exposed part or crown; and the cement covers with a thin layer the surface of the implanted portion or fang.

A. The *ivory*, *tooth substance*, or *dentine*,[1] (Owen,) forming the principal mass or foundation of the body and root of a tooth, gives to both of these parts their general form, and immediately encloses the central cavity (2). It resembles very compact bone in its general aspect and chemical relations, but is not identical with it in structure, or in exact proportions of its earthy and animal constituents.

According to the analyses of Berzelius and Bibra, the dentine of human teeth consists of 28 parts of animal, and 72 of earthy matter. The former we have found to be resolvable into gelatin by boiling, as is generally believed, although Bibra describes it as similar to chondrin, mixed with a little fat. The latter is composed of phosphate of lime with traces of fluoride of calcium, the proportion being, according to Bibra, 66·7 pr. ct., carbonate of lime, 3·3, phosphate of magnesia and other salts, 1·8. Berzelius found 5·3 parts of carbonate of lime.

Though appearing to the naked eye to have a compact structure, the dentine, when examined under the microscope, is seen to consist

Fig. 420.

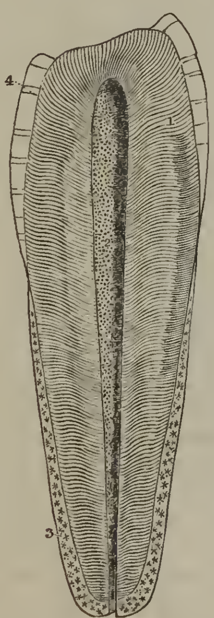


Fig. 421.

Fig. 420. After Retzius. — Magnified representation, or rather diagram, of a bicuspid tooth divided longitudinally. 1. The ivory or dentine, showing the direction and primary curves of the dental tubuli. 2. The pulp-cavity, showing the orifices of the tubuli. 3. The crusta petrosa or cement covering the fang as high as the border of the enamel at the neck. The stars indicate that it contains lacunæ like those of bone. 4. The enamel resting on the dentine.

Fig. 421. Section of the dentine made across the tubuli, highly magnified. After Retzius. 1, 2, 3. Dentinal tubes in transverse section, exhibiting their cavity and walls. 4, 5, 6. The tubuli obliquely cut.

of an immense number of very fine tubes, having distinct parietes, and passing very close to each other, through a hard intermediate substance, named the intertubular tissue. These tubes, called *dental tubuli*, were long since discovered and described by Leeuwenhoek,

but his observations were disregarded until the tubular structure was again brought to light through the modern researches of Purkinjé and Retzius, by whom, and by others, it has now been very minutely examined and described. The tubules of the dentine open at their inner end into the pulp-cavity, appearing as minute orifices on its sides ([2]). From thence they pass in a radiated manner through every part of the ivory towards its periphery. In the upper portion of the crown they have a vertical direction; but towards the sides, and in the neck and root, they become gradually oblique, then horizontal, and are finally even inclined downwards towards the point of the fang. The course of the tubules is not straight, but each describes, in passing from the central to the peripheral part of the dentine, two or three gentle curves (*primary* curvatures, Owen), and is besides bent throughout its whole length into numerous fine undulations, which follow closely upon one another; these are the *secondary* curvatures. In adjacent tubules both kinds of curvatures so far correspond that the tubes themselves are nearly parallel, being only slightly divergent from each other; and as they divide several times dichotomously, and at first without being much diminished in size, they continue to occupy the substance of the dentine with nearly equidistant tubes, and thus produce, when seen in fine sections of the tooth made parallel to their course, a striated appearance, as if the dentine were made up of fine parallel fibres. The concurrence of many of these parallel curvatures of the dental tubuli produces, by the manner in which they reflect the light, an appearance of concentric lines in the dentine, see fig. 420, which may be well seen with a low magnifying power. The average diameter of each tubule near its inner and larger end is $\frac{1}{4500}$ of an inch, and the distance between adjacent tubules is about two or three times their width. (Retzius.) From their sides numerous immeasurably fine branches are given off, which penetrate the hard intertubular substance, where they either anastomose or terminate abruptly, or, according to some, end in very minute cells. These lateral ramuscles are said to be more abundant in the fang. Near the periphery of the ivory they are very numerous, and, together with the main tubules themselves, which there, by rapid division and subdivision also become very fine, terminate by joining together in loops, or end in little dilatations, from which other ramuli are given off, or in minute cells. They are also occasionally seen to pass on into the cement which covers the fang, and to communicate with the small ramified canals of the characteristic lacunæ found in that osseous layer. The minute cells belonging to the intertubular substance of the human tooth are very few in number and small, and hence not conspicuous, but they are larger and more numerous in the tooth of the horse. They are most distinct in the outer layer of the dentine, which is immediately beneath the enamel or cement, and is named the *granular* layer by Purkinjé. The surface of the dentine where it is in contact with the enamel is marked by undulating grooves and ridges, and also by numerous minute hexagonal depressions, to which the microscopic fibres of the enamel are accurately adapted.

The dental tubules, when highly magnified, appear like dark lines

against transmitted light, but are white when seen upon a black ground. This is owing either to their containing an opaque granular calcareous deposit, as some suppose, or merely to a certain degree of opacity of their parietes. Their tubular character is proved by the fact that ink, and other fluids, together with minute bubbles of air, have been seen to pass along them. Their walls are comparatively thick, and are readily distinguishable from the intertubular substance, as may be seen in a transverse section, similar to that figured by Retzius, fig. 421. In the temporary, and sometimes even in the permanent teeth, the tubules are constricted at short intervals, so as to present a moniliform character. (Nasmyth, Owen, Tomes.)

The *intertubular substance* is translucent, and finely granular (Tomes); it contains the greater part of the earthy substance of the dentine. The animal basis which remains after this has been removed by an acid, is described by Henlé as separable into bundles of pale flattened granular fibres running in a direction parallel with the tubes, and by Nasmyth as consisting of brick-shaped cells, built up, as it were, around the tubules, which, we may remark, are by this observer regarded as solid fibres. Neither of these statements, however, is easily reconcilable with what we have observed in the softened teeth of the cachalot or sperm whale; for in these the animal substance can be readily torn into fine lamellæ, disposed parallelly with the internal surface of the pulp-cavity, and therefore across the direction of the tubules. In these lamellæ the sections of the tubules appear as round or oval apertures, the lamellæ having the same relation to the tubules as those of true bone to the canaliculi.

B. The *enamel* (fig. 420,[4]) is that hard white covering which encrusts and protects the exposed portion or crown of a tooth. It is the hardest of all the dental tissues, but it becomes worn down by protracted use. It is thickest on the grinding surface and cutting edges of the teeth, and becomes gradually thinner towards the neck, where it ceases. Its extent and thickness are readily seen on charring the tooth, by which the dentine becomes blackened, whilst the enamel, owing to the very small quantity of animal matter in its composition, remains white. According to Bibra, it contains of earthy constituents 96·5 per cent., viz., phosphate of lime with traces of fluoride of calcium 89·8, carbonate of lime 4·4, phosphate of magnesia and other salts 1·3; and has only 3·5 per cent. of animal matter. Berzelius, however, gives the proportion of carbonate of lime as 8, and of animal matter as only 2 per cent.

The enamel (fig. 421,[4]) is made up entirely of very hard and dense microscopic fibres of prisms, composed almost wholly of earthy matter, arranged closely together, side by side, and set by one extremity upon the subjacent surface ([1]) of the dentine ([2]). On the summit of the coronal portion of the tooth, these enamel fibres are directed vertically, but on the sides they are nearly horizontal. As seen on a section they are disposed in gently waving lines, parallel with each other, but not so regular as the curvatures of the tubuli of the dentine, with which they have no agreement. The concurrence of these parallel curvatures produces, as in the case of the dentine, an appearance of

concentric lines (5) in the enamel, which may be seen with a lens of low power. Minute fissures not unfrequently exist in the deep part of the enamel, which run between clusters of the fibres down to the surface of the dentine; and other much larger and evident fissures are often observed leading down from the depressions or crevices between the cusps of the molar and premolar teeth. The surface of the enamel, especially in the milk teeth, is marked by concentric ridges, which may be distinguished with a common magnifying glass, and which are probably occasioned by the ridges and furrows already described upon the coronal portion of the dentine.

The enamel fibres are described by Retzius as being solid hexagonal prisms, but by others they are said rather to be four-sided. Their diameter varies slightly, and is ordinarily about $\frac{1}{500}$ of an inch. They are marked at small intervals by dark transverse lines, (fig. 424.)

Fig. 422.

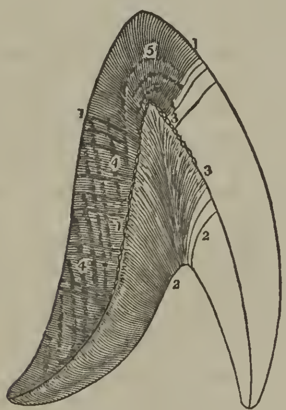


Fig. 423.

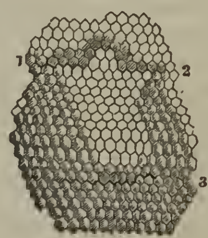


Fig. 424.

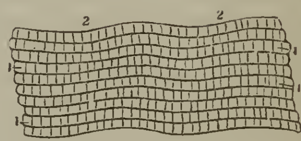


Fig. 422. A vertical section of an imperfectly developed incisor, taken from the follicle in which it was enclosed; this section is meant to show the position of the enamel fibres, and also that a part of the appearances which are seen in this substance under a less magnifying power, originate in parallel curvatures of the fibres; 1, 1, the enamel; 2, 2, the dentine, or ivory; 3, 3, the minute indentations and points on the surface of the ivory, on which the enamel fibres rest; 4, 4, parallel enamel fibres; 5, parallel flexions of the fibres of the dentine in these stripes.

Fig. 423. A portion of the surface of the enamel on which the hexagonal terminations of the fibres are shown—highly magnified; 1, 2, 3, are more strongly marked dark crooked crevices, running between the rows of the hexagonal fibres.

Fig. 424. The fibres of the enamel viewed sideways under a magnifying power of 350 times; 1, 1, the enamel fibres; 2, 2, the transverse stripes upon them.—C.]

According to Mr. Tomes, the fibre is not in all cases solid, but has an extremely minute cavity in part or whole of its length, which is best seen in newly developed enamel, but is also visible in adult teeth. Their inner ends are implanted, as it were, into the minute hexagonal depressions found on the surface of the dentine, whilst the outer ends, somewhat larger in diameter, are free, and present, when examined with a high magnifying power, a tessellated appearance.

On submitting the enamel to the action of dilute acids, it is almost

entirely dissolved, and leaves scarcely any discernible traces of animal matter. Near the deep surface this is rather more abundant, according to the observations of Retzius, who conceived that it there aided

[Fig. 425.

Fig. 426.

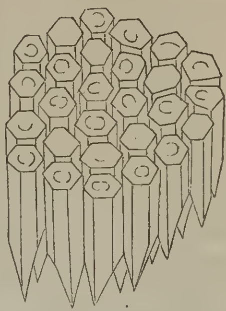


Fig. 425 represents a portion of enamel from a human incisor tooth before its eruption. The mass to the left, was taken from the exterior part of the enamel, and exhibits the transverse truncation of the fibres upon the free surface of the enamel, and the oblique truncation at the other extremities.

Fig. 426. Hexagonal prisms of enamel, highly magnified, from the exterior part of the enamel of an embryo incisor tooth. Circular outlines were seen upon the free, transversely truncated extremities, which I presumed to be the outline of the nucleus.—From nature, by J. L.]

in fixing the enamel fibres. By the aid of an acid, the enamel of newly formed or still growing teeth, may be broken up, and its structural elements more easily distinguished. The prisms are then found to have interposed between them a delicate membranous structure representing, in fact, the walls of cells which have coalesced and formed moulds for the deposition of the calcareous matter. As this latter accumulates the membranous structure becomes almost or entirely obliterated, and the now earthy prisms are inseparably consolidated. The transverse striæ are considered by Retzius and others as the indication of the pre-existing walls of coalesced cells.

[The structure of the enamel may be best studied on the tooth before its eruption; at this period the enamel fibres or prisms are readily separated from one another (fig. 425).

The fibres present the appearance of transparent and pretty regular hexagonal prisms, but instead of being terminated at the extremities by a surface at right angles to the length of the fibres, it has always appeared to me to be oblique, and the striæ, which are usually represented as being transverse, appear to have the same course as the obliquely truncated extremities of the fibres. These prisms readily break up into very minute hexagonal facets, along the course of the oblique striæ.

The membrane (fig. 429) which surrounds the enamel fibres, is also marked with oblique striæ corresponding to those of the fibres.

The fibres originate in nucleolo-nucleated cells (fig. 430), which, at first spherical, become elongated and take upon themselves the form of the future enamel fibres (fig. 427).

After the calcification of the interior of the enamel cells, which appears to have a regular disposition of thin laminæ, giving rise to the oblique striæ of the enamel fibres, the cell-wall for a time is readily separable, but finally becomes obliterated.

The enamel fibres, forming the exterior part of the enamel, upon the free surface of the latter, are transversely terminated (fig. 426).—J. L.]

The third substance which enters into the formation of the teeth is the *crusta petrosa* or *cement* (fig. 420,[3]). This is a layer of true bone,

slightly modified in structure, which invests that part of the dentine which is not protected by the enamel. It covers the whole fang,

[Fig. 427.

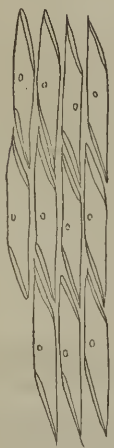


Fig. 428.

Fig. 429.

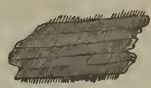


Fig. 430.

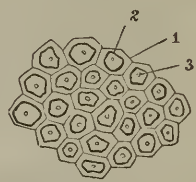


Fig. 427. Enamel cells from an embryo canine tooth, highly magnified, the contents calcified but still in a very friable condition. The nucleoli were visible.

Fig. 428. Several enamel fibres, from an embryo molar, highly magnified and exhibiting the obliquely truncated extremities. In one the oblique striæ are represented, in the course of which the fibres have a great disposition to fracture.

Fig. 429. A portion of membrane which surrounds the enamel fibres, highly magnified, from an embryo incisor. It exhibits the oblique striæ, corresponding to those of the enamel fibres.

Fig. 430. Transverse section of enamel cells, calcified, highly magnified, from an embryo incisor, exhibiting the cell-wall (1), the nuclei (2), and the nucleoli (3).—From nature, by J. L.]

towards the lower end of which it becomes gradually thicker, and is especially developed at the apex, and along the grooves of the compound fangs. Besides this it has been traced by Purkinjé, Nasmyth, and Owen, as a very thin layer, which, however, soon gets worn off, over the enamel upon the crown; and in the compound teeth of many herbivorous animals, the existence of this coronal cement is evident enough. As life advances the cement is generally found to become thicker, especially near the apex of the fang, where it sometimes blocks up the orifice leading into the pulp-cavity.

The crusta petrosa contains cells and canaliculi resembling those of bone; they are placed lengthwise around the fang, and give off minute radiated ramifications, which are often found to proceed from one side only of a cell, towards the *periodontal* surface (Tomes). These cells have not been seen in the coronal cement of human teeth, but only in that of the implanted portion: in the deep layers of the cement, the fine canaliculi sometimes anastomose with some of the terminal tubules of the subjacent dentine. Where the cement is very thick, it may contain vascular canals, analogous to the Haversian canals of bone. On the deciduous teeth the cement is thinner and contains fewer cells. In chemical composition it resembles bone and contains 30 per cent of animal matter. The cement is, according to some, extremely sensitive at the neck of the tooth, if it be exposed by retraction of the gum. By its connexion with the surrounding membranous

structures it contributes to fix the tooth in the socket. It is the seat of the bony growths or exostoses sometimes found upon the teeth.

It has been long observed that, after the age of twenty years or later, the central cavity of a tooth becomes gradually diminished in size, by the deposit of a hard substance on the inner surface of the dentine, whilst the pulp slowly shrinks or disappears. This additional substance, once considered to be an extension of the cement into the interior of the tooth, has been shown to have a distinct structure, in part resembling dentine, and in part bone. It is the *horny substance* of Blumenbach, and is named *osteodentine* (Owen), and *secondary dentine* (Tomes). It is traversed by canals, which contain blood-vessels, and are surrounded by concentric lamellæ, like the Haversian canals of bone. From these canals, numerous tubules radiate in all directions, but have no calcigerous cells connected with them; moreover, the tubules are larger than those of bone, resembling, in this respect, and also in their mode of ramification, the tubes of the dentine. This newly added structure may or may not coalesce with the previously formed dentine; it appears to be produced by a slow conversion of the dental pulp.

DEVELOPMENT OF THE TEETH.

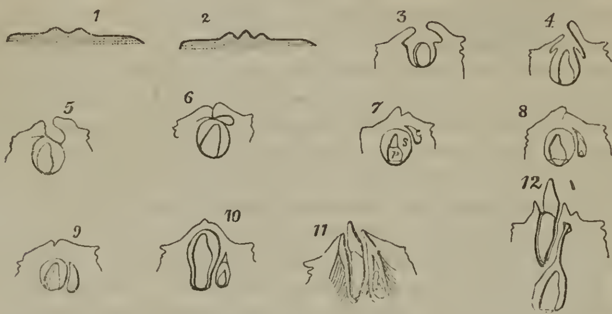
The development of the teeth includes a description of their origin and growth, as distinct organs,—of their order of eruption in two sets,—and also an account of the formation of their component tissues, the dentine, enamel, and cement.

The recent observations of Arnold and Goodsir, made independently of each other, have given precision to our knowledge concerning the origin and mode of growth of the teeth, and have fully established the fact, that the teeth are developed from the mucous membrane covering the edges of the maxillary arches. The changes which take place in the bones of the jaws relate only to the formation of the sockets for the teeth. In the earliest condition these bones present no appearance of alveoli, but, concurrently with certain changes in the mucous membrane, to be immediately described, a wide groove is developed along the edge of the jaw, which gradually becomes deeper, and is at length divided across by thin bony partitions, so as to form a series of four-sided cells. These bony septa are not distinctly formed until nearly the fifth month of fœtal life. By the subsequent growth of the bone, these cavities or loculi are gradually closed round, but always continue open at the edge of the jaw. By the end of the sixth month they are distinctly formed, but continue afterwards, (see figs. 63, c, and 74, pp. 142 and 150,) in proportion to the growth of the teeth, to increase in size and depth, by the addition of new matter, which widens and deepens the jaw.

The first stages in the development of the teeth, as observed by Arnold and Goodsir, consist of certain changes in the mucous membrane covering the borders of the maxillæ. (Consult fig. 431, and its description.) About the sixth week of embryonic life, a depression or groove, having the form of a horseshoe, appears along the edge of the jaw, in the mucous membrane of the gum; that is the *primitive dental* groove (Goodsir). From the floor of this groove (supposed to

be represented in a transverse section, in fig. 431, 1) a series of ten papillæ, as at 2, arise in succession in each jaw, and constitute the germs or rudimentary pulps of the milk teeth. The order in which

[Fig. 431.



From Goodsir.—A series of diagrams, representing imaginary *sections* made across the edge of the lower jaw of the fœtus at different periods, in order to show the successive stages in the development of the sac of a temporary incisor tooth, and of the succeeding permanent tooth, from the mucous membrane of the jaw.—1. The dental groove is formed in the mucous membrane. 2. The groove widens, and has a papilla at the bottom: this is the papillary stage. 3, 4, and 5 represent the follicular stage; the lips of the groove enlarge, and form a sunken follicle, in which the papilla, now enlarged and beginning to acquire the form of the future tooth-pulp, is hid. Membranous opercula, or laminæ, are formed from the sides of the follicle, and, as seen in 5, meet over, leaving a lunated depression behind. The diagram, 5, supposing the opercula to be gently opened out, may be taken to represent a cross section through an incisor follicle, as indicated by the dotted line *a b*, fig. 436. 6. The lips of the groove also meet, except the lunated depression, *c*. 7. The opercula and lips of the groove cohere; the follicle becomes a closed sac (*s*); the papilla is the tooth-pulp (*p*), and has the shape of the crown of the future tooth; and the lunated depression becomes a cavity of reserve (*c*) for the development of the succedaneous permanent tooth: the saccular stage is now complete. The remaining figures, 8 to 12, show the commencement of the cap of dentine on the pulp, the subsequent steps in the formation of the milk tooth, and its eruption through the gum (11); also the gradual changes in the cavity of reserve, the appearance of its laminæ and papilla, its closure to form the sac of the permanent tooth, its descent into the jaw, behind and below the milk-tooth, and the long pedicle (12) formed by its upper obliterated portion.

these papillæ appear is very regular. The earliest is that for the first milk molar tooth; it is seen at the seventh week, as soon as the dental groove is formed; at the eighth week that for the canine tooth appears; the two incisor papillæ follow next, at about the ninth week, the central one before the lateral; lastly, the second molar papilla is visible at the tenth week, at which period this, the *papillary stage* (2) of the rudiments of the teeth is completed. The papillæ in the upper jaw appear a little earlier than those in the lower jaw.—In the next place, the margins of the dental groove become thickened and prominent, especially the inner one; and membranous septa pass across between the papillæ from one margin to the other, so as to convert the bottom of the groove into a series of follicles, each containing one of the papillæ. These changes constitute the *follicular stage* (3); they take place in the same order as that in which the papillæ appeared, and are completed about the fourteenth week (fig. 431, 4, and fig. 432). During the early part of this period the papillæ grow rapidly, they begin to show peculiarities of form, and project from the mouths of the follicles. Soon, however, the follicles become deeper, so as to hide the papillæ (fig. 432), which now assume a shape corresponding with that of the crowns of the future teeth. Small laminæ, or opercula

of membrane (fig. 431, 4 and 5), are then developed from the sides of each follicle, their number and position being regulated, it is said, by the form of the cutting edges and tubercles of the intended teeth: the incisor follicles (fig. 436,[3],[4]) having two laminæ (*o*), one external and one internal; the canine ([3]), three, of which two are internal, and the molars ([1], [5]) four or five each.—The lips of the dental groove, as well as the opercula, now begin (fig. 431, 6) to cohere over the follicles from behind forwards, the posterior lip being very much thickened; the groove itself is thus gradually obliterated (7), the follicles are converted into closed sacs (*s*), and the *saccular stage* of the milk teeth is thus completed about the end of the fifteenth week. Certain lunated depressions (5, 6, *c*, also fig. 436, *c*), which are formed one behind each of the milk follicles about the fourteenth week, escape the general adhesion of the lips of the groove. From these depressions, as will be afterwards described, the sacs of the ten anterior permanent teeth are subsequently developed.

Fig. 432.

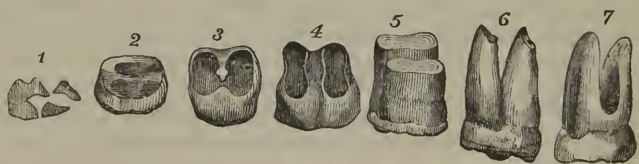
An enlarged view of the upper jaw and palate of a fœtus at about the fourteenth week, showing the follicular stage of the development of the milk teeth. The ten follicles, each containing a papilla, are distinctly seen.

The *dental sacs* (fig. 431, 7 *s*), thus formed by the closure of the follicles, continue to enlarge, as well as their contained papillæ (*p*). The walls of the sacs, which soon begin to thicken, consist of an outer fibro-cellular membrane, and an internal highly vascular layer, lined by epithelium; their blood-vessels are derived partly from the dental arteries which course along the base of the sacs, and partly from those of the gums.

The papillæ, now the dental pulps, adhere by a wide base to the bottom of the sacs, and, having acquired a perfect resemblance to the crowns of the future teeth, the formation of the hard substance commences in them. This process begins very early, and by the end of the fourth month of fœtal life, thin shells or caps of dentine are found on all the pulps of the milk teeth, and a little later on that of the first permanent molar. The mode in which it proceeds, taking a canine tooth as an example, may be stated as follows: a thin osseous shell or cap of dentine appears on the point of the pulp; this increases in extent by a growth around its edges, and in thickness by a similar formation in its interior, the latter taking place at the expense of the substance of the pulp itself, which accordingly decreases in proportion. This growth of the tooth continues until the crown is completed of its proper width, and then the pulp undergoes a constriction at its base to form the cervix of the tooth. From that time the pulp elongates and continues to become narrower, so as to construct the fang (10, 11). During the whole period, another process has been going on, by which the outer surface of the crown is covered with the enamel. This substance is formed from a thickened portion of the parietes of the

sac, which is accurately adapted to the surface of the dental pulp, or to its cap of dentine, and was called by Hunter the *outer* pulp. Sooner or later, after the completion of the crown, this part of the tooth appears through the gum (11), whilst the growth of dentine to complete the fang is continued at the surface of the elongating pulp, which gradually becomes encroached upon by successive formations of hard substance, until only a small cavity is left in the centre of the tooth, containing nothing but the reduced pulp, supplied by a slender thread of vessels and nerves, which enter by a little aperture left at the point of the fang after the dentine is completed. In the case of teeth, having complex crowns and more than a single fang, the process is somewhat modified. On the surface of the dental pulp of such a tooth, as many separate little shells of dental substance are formed as there are eminences or points (fig. 433, [1]); these soon coalesce ([2]), and the formation of the tooth proceeds as before as far as the cervix. The pulp then becomes divided into two or more portions, corresponding with the future fangs, and the ossification advances in each as it does in a single fang. A horizontal projection or bridge of dentine (3, 4) shoots across the base of the pulp, between the commencing fangs, so that if the tooth be removed at this stage and examined on its under surface, its shell presents as many apertures as there are separate fangs. In all teeth, the pulp originally adheres by its entire

Fig. 433.



Shows the mode of formation of a molar tooth with two fangs. (Blake.)—1. Distinct caps of dentine, which afterwards unite. 2, 3. A bridge of dentine is beginning to stretch across the base of the tooth-pulp, and is completed in 4. Henceforth the pulp is double, and each part forms its own fang.

base to the bottom of the sac, but when more than one fang is to be developed, the pulp is, as it were, separated from the sac in certain parts, so that it comes to adhere at two or three insulated points only, whilst the dentine continues to be formed along the intermediate and surrounding free surface of the pulp.

Formation of the hard tissues of the teeth.—a. The Dentine.—It was at one time supposed that this substance was formed by a process of ossification similar to what takes place in the cartilages of true bones; but this opinion subsequently gave way to another, which prevailed until lately, and attributed the formation of the tooth to a process of secretion from the surface of the pulp. The older notion has since been revived by Schwann, in applying his doctrine of the development of tissues from cells, to the observations previously made by Purkinjé and Raschkow. By these last-named inquirers, the dentine was described as being formed in continuous layers from without inwards, the pulp supplying the material: Schwann expressed his

opinion, that it was in reality the *ossified pulp*. This doctrine has received general support from subsequent observers, and it may be regarded as established; but the precise changes which accompany the conversion of the pulp into dentine, are not yet satisfactorily determined.

Previously to the commencement of ossification, the primitive pulp is found to consist of microscopic nucleated cells (pulp-granules, Purkinjé), more or less rounded in form, and embedded in a clear matrix containing a few very fine molecules, thinly disseminated in it. It contains no cellular fibres, but is highly vascular. The capillary vessels are most abundant at the points where ossification is to commence, but do not reach the surface. At the exterior of the pulp, the rounded cells become elongated, and arranged perpendicularly to the surface, so as to form a tolerably regular layer, resembling a columnar epithelium. Besides this, the entire pulp is covered by a fine pellucid homogeneous membrane, named the *preformative membrane* (Purkinjé, Raschkow).

In the process of ossification, as described by Schwann, the elongated cells, at the surface of the pulp, together with the intercellular matrix, become gradually solidified by impregnation with earthy matter, and are thus converted into dentine. Similar changes of elongation, apposition, and solidification by earthy deposit, occur in successive layers of cells, which go on being developed in the pulp. The *preformative membrane* is either obliterated, or according to Purkinjé, Retzius, and Raschkow, is the part first to undergo ossification, which then proceeds to affect the tissue of the pulp immediately beneath it. The granular layer (Purkinjé) found upon the surface of the dentine next to the enamel, and in which the microscopic cells are chiefly found, is conjectured to result from the ossification of this membrane; and the enamel fibres are supposed to be implanted in the minute hexagonal depressions formed on its outer surface. This preformative membrane was noticed by Mr. T. Bell, who thought, however, in accordance with the views then generally entertained, that the dentine was deposited on its outer surface. On gently separating the newly formed cap of dentine from the formative pulp, in the growing teeth of the human subject or of animals, and examining it under the microscope, the elongated cells of the pulp are found adhering in numbers to the inner surface of the newly formed dentine. The hard substance undoubtedly increases at the expense of the pulp, and different observers have described the mode in which the pulp-cells, their nuclei and the intercellular matrix, are converted into the tubuli and intertubular substance of the dentine; but from our own observations we have not been able to confirm these descriptions, and we are disposed to regard the precise nature of the conversion of the soft tissue into the dentine as still a matter for investigation.

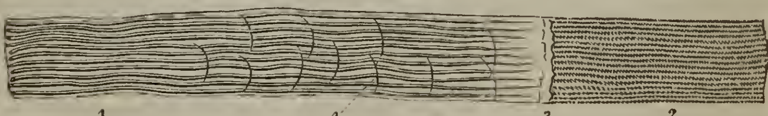
Schwann at first conceived that the tubuli were prolongations of the cells, and that the intertubular substance was formed by the calcification of the matrix, but he abandoned this idea after comparative researches in animals. Henlé thought that the cells, in becoming impregnated with earthy matter, formed the bundles of fibres of which the dentine is supposed by him to consist; whilst the nuclei became elongated into the hollow tubes. Owen believes that the nuclei of the

elongated cells, having themselves become lengthened, divide both longitudinally and transversely to develope secondary cells which continue included within the primary cells.* These secondary cells then elongate and together with their nuclei join end to end. Calcification proceeds in all parts, except in the nuclei of the secondary cells which remain as the cavities or lumina of the tubes; the walls of the secondary cells are supposed to form the parietes of the tubes, and the material between the secondary cells together with the walls of the primary cells to be converted into the intertubular substance. The bifurcation of the tubuli is said to result from the junction of two secondary cells with a single one in a deeper layer of the pulp; and the constricted or moniliform appearance of the tubuli already mentioned as having been seen by some observers in growing or even in mature teeth, is thought to depend on an imperfect coalescence of the nuclei. In the teeth of young animals, Mr. Tomes states that he has noticed the division of the cells and their subsequent coalescence to form the tubes, but he has failed to recognise the existence of primary cells including secondary ones. We must confess, that, after a careful examination of the human teeth, we have been unable to discover any of the above described changes, except the enlargement of the more superficial cells of the pulp and their elongation in the immediate vicinity of the dentine.

b. The Enamel.—This substance is formed by a peculiar organ developed in the outer wall of the sac, at the same time that the dentine is being produced by the pulp. Its formation commences very early. The membranous wall of the sac, soon after its opercula have united together, becomes thickened and pulpy, and at length applies itself in the form of a soft mass accurately adapted to the surface of the primitive dental pulp, or at a later period to the cap of dentine. This thickened part of the sac is the *outer* pulp of Hunter, which, as he stated, is the formative organ of the enamel (*organon adamantinæ.* Purkinjé). The structure of this enamel pulp is very remarkable: it is described by Todd and Bowman as consisting of an open web of distinct fibres, holding within their reticulations a clear fluid, and having a bright spot at their place of junction. The same structure was previously described by Purkinjé and Raschkow, as formed by radiating cells, like the actinenchyma of vegetable tissues. The surface of this structure, turned towards the inside of the dental sac, is covered with a fine transparent simple membrane, upon which rests a thick stratum of nucleated cells, which compose the *enamel membrane* (*membrana adamantinæ*, Purkinjé), a structure analogous to epithelium. From the vascular part of the enamel pulp, villous processes, containing blood-vessels, project into the enamel membrane, at the part corresponding with the grinding surface of the tooth. At first,

[* In sections of dentine, in most instances, and especially towards its outer periphery, numerous curved lines (fig. 434,[4]), are observed, which Mr. Owen regards as the original contour of the primary dentinal cells.

Fig. 434.



Section of the crown of a human molar tooth, highly magnified. 1. Dentine. 2. Enamel. 3. Periphery of the dentine or base upon which the enamel fibres are placed. 4. Curved outlines indicating the original contour of the primary dentinal cells.—J. L.]

the layer of cells composing the enamel membrane is in contact with the dental pulp. When, however, the shell of dentine begins to be formed, a succession of those nucleated cells, uniting in rows, arrange themselves vertically to its surface, become elongated and prismatic, and being impregnated with earthy matter, form the solid prismatic fibres of the enamel, which coalesce firmly together. Whilst the enamel is being formed, it is soft and chalky, and can easily be separated into its component cells. Afterwards the membranous portion of it is nearly all obliterated, and the nuclei entirely disappear, or according to Tomes, elongate into a very fine central canal in each fibre. No enamel is formed except on the crown of the tooth; either because the enamel pulp adheres to the cervix, or because the character of the membrane of the sac changes at that point.

c. *The Cement.*—This osseous layer appears to be formed, simultaneously with the dentine of the fang, by the periodontal membrane, from the margin of the enamel downwards. As to the origin of the coronal cement, it is supposed by some that the enamel membrane itself, after its proper function has ceased, is converted into that substance, and by others that it pours out a material which subsequently becomes ossified.

Eruption of the temporary teeth.—At the time of birth (fig. 435) the crowns of the anterior milk teeth, still enclosed in their sacs, are completed within the jaw, and their fangs begin to be formed. Their appearance through the gums follows a regular order, but the period at which each pair of teeth is cut varies within certain limits. The

Fig. 435.

a, Left, and *b*, right, half of the lower jaw of a child at birth, with part of the bone taken away to show the tooth-sacs as they lie underneath the gum. The lower figure shows the sacs of the milk teeth and first permanent molar, exposed by removing the bone from the outside; the upper figure shows the same from the inside, with the sacs of the permanent incisors and canine lying behind those of the corresponding milk teeth.

eruption commences at the age of seven months, and is completed about the end of the second year. It begins with the central incisors of the lower jaw, which are immediately followed by those of the upper jaw; and, as a general rule, each of the lower range of teeth rises through the gum before the corresponding tooth of the upper set.

The following scheme indicates in months, the order and time of eruption of the milk teeth.

MOLARS.	CANINES.	INCISORS.	CANINES.	MOLARS.
24—12	18	9 7 7 9	18	12—24

Before the teeth protrude through the gum, this undergoes some peculiar changes: its edge at first becomes dense and sharp, but as the tooth approaches it, the sharp edge disappears, the gum becomes rounded or tumid, and is of a purplish hue; the summit of the tooth is seen like a white spot or line through the vascular gum, and soon after rises through it. As the crown of the tooth advances to its ultimate position, the elongated fang becomes surrounded by a bony socket or alveolus. Before the eruption, the mucous membrane is studded with a number of small white bodies, which were described by Serres, as glands (*dental glands*), and were supposed by him to secrete the tartar of the teeth. Meckel thought they were small abscesses, because no aperture could be detected in them. As examined in a fœtus of six months, we have found them to be little round pearl-like bodies situated in the chorion of the mucous membrane, and having no aperture. They are small spherical capsules of various sizes, lined with a thick stratum of epithelium, the inner cells of which are flattened or scaly, like those lining the cheek, and are so numerous as almost to fill up the cavity.

Development of the permanent teeth.—The preceding description of the structure of the dental sacs and pulps, and of the mode of formation of the several parts of a tooth, applies to the permanent, as well as to the milk teeth.

The origin and progressive development of the sacs of the permanent teeth, have still to be considered. There are six more permanent teeth in each jaw than there are milk teeth, and it is found that the sacs of the ten anterior permanent teeth, which succeed the ten milk teeth, have a different mode of origin from the six additional or superadded teeth, which are formed further back in the jaw.

The sacs and the pulps of the ten *anterior permanent* teeth have their foundation laid before birth, behind those of the milk set; and as they are found, after a time, attached to the sacs of the temporary teeth, (figs. 435, 439,) it was conceived that they sprouted or shot out from these latter. This has been disproved by the observations of Goodsir, who has shown that the sacs of the ten anterior permanent teeth are developed from the dental groove, independently of the milk sacs. Recurring to the follicular stage of the temporary teeth, which is completed about the fourteenth week (see pp. 418-19), it will be remembered that behind each milk follicle there is formed a small lunated recess, (fig. 431, 5, 6; and fig. 436,[c]) similar in form to an impression made by the nail. As already stated, the mucous membrane lining these recesses escapes the general adhesion of the lips and sides of the dental groove, so that when the latter closes they are converted into so many cavities, which are called by Mr. Goodsir, "*cavities of reserve*," (fig. 431, 7.[c]) They are ten in number in each jaw, and are formed

successively from before backwards. They ultimately form the sacs for the incisor, canine, and bicuspid permanent teeth. These cavities soon elongate and recede into the substance of the gum behind the milk follicles, above and behind in the upper jaw, below and behind in the lower (8 to 12). In the mean time, a papilla appears in the bottom of each (that for the central incisor appearing first, at about the sixth month), and one or more folds (8, 10), or opercula, as in the case of the temporary teeth, are developed from the sides of the cavity, and by their subsequent union, divide it into two portions, the lower portion containing the papilla, and now forming the dental sac and pulp of the permanent tooth; and the upper and narrower portion being gradually obliterated in the same manner as the primitive groove was closed over the milk-sacs (10, 11). When these changes have taken place, the permanent sac adheres to the back of that for the temporary tooth. Both of them continue then to grow rapidly, and after a time it is found that the bony socket not only forms a cell (fig. 437, b') for the reception of the milk sac (b), but also a small posterior recess or niche (a'), for the permanent sac (a), with which the recess keeps pace in its growth. Confining our description now, for convenience, to the lower jaw only, it is found that at length the permanent sac so far recedes in the bone as to be lodged in a special osseous cavity at some distance below and behind the milk tooth, the two being completely separated from each other by a bony partition (figs. 437, 438, 439). In descending into the jaw, the permanent sac (fig. 437, a, a, a,) acquires at first a pear-shape, and is then connected with the gum by a solid membranous pedicle, c. The recess in the jaw has a similar form: it presents a cell, $á$, $á$, for containing the sac itself, which is drawn out into a long canal, c', c', opening on the edge of the jaw, by an aperture seen behind the corresponding milk tooth (fig. 438, c'). This canal lodges the above-mentioned membranous pedicle. The permanent tooth (a), which is developed from its dental pulp and enamel pulp, in the manner already described, is separated from the socket and root of the milk tooth by a bony partition, against which, as well as against the root of the milk tooth, b, just above it, it presses in its rise through the gum, so that these parts are in a greater or less extent absorbed. When this has proceeded

Fig. 436.

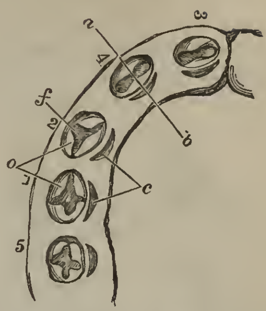


Diagram of the left half of the lower jaw at about the fourteenth week, slightly altered from Goodsir. It is considerably magnified, to show the follicles of the milk teeth opened out, their opercula, and the position of the lunated recesses behind them, from which the sacs of the five anterior permanent teeth are developed.—1 to 5. Milk-teeth follicles, numbered in their order of appearance and formation. 1. First molar. 2 Canine. 3. Central incisor. 4 Lateral ditto. 5. Second molar. *a*, *b*. A dotted line to indicate the direction in which the cross sections, represented in fig. 432, are supposed to be made; such a section carried through the follicle for the second incisor would correspond best with diagram 5 in that cut, supposing the opercula and the lips of the follicles were not opened out. *f*. The cavity of the follicle, the papilla being hid. *o*, *o*. The opercula. *c*. Lunated depressions, which resist the subsequent adhesion of the mucous membrane, and become the cavities of reserve for the permanent teeth.

far enough, the milk tooth becomes loosened, falls out or is removed, and the permanent tooth then takes its place. The milk teeth and the permanent teeth are said by Serres to be supplied by two different arteries, the obliteration of the one going to the temporary teeth, being regarded by him as the cause of their destruction, but of this there is no sufficient proof.

Fig. 437.

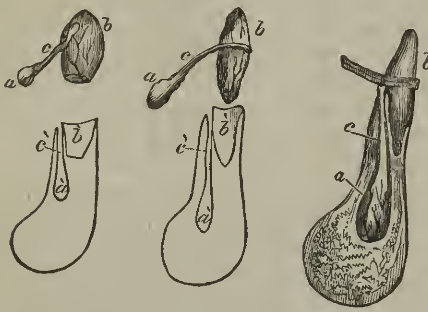


Fig. 438.

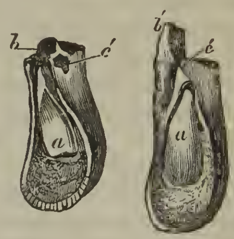


Fig. 437. After Blake, with additions in outline.—These figures are intended to show the relation between the sac of the milk tooth and that of the corresponding permanent tooth, together with the relation of both to the substance of the lower jaw. In all cases *a* is the sac of the permanent tooth, *c* its pedicle, *b* that of the milk tooth, or the milk tooth itself. *a′*, *b′*, and *c′*, in the diagrams below indicate the two recesses, with the intermediate canal, in which the parts *a*, *b*, and *c*, are lodged in the jaw.

Fig. 438. After Blake.—Position of a milk and a permanent tooth in the lower jaw.—*a*. Permanent tooth. *b*. Milk tooth, or its socket. *c*. Orifice of a canal in the bone, which transmits the pedicle of a permanent tooth sac.

The six *posterior* (or "*superadded*") *permanent* teeth, that is, the three permanent molars on each side, do not come in the place of other teeth. They arise from successive extensions of the dental groove carried backwards in the jaw, posterior to the milk teeth, and named "*posterior cavities of reserve.*"

During the general adhesion of the dental groove occurring at the fifteenth week, the part posterior to the last temporary molar follicle continues unobliterated, and thus forms a cavity of reserve, in the fundus of which a papilla ultimately appears, and forms the rudiment of the first permanent molar tooth: this takes place very early, viz., at the sixteenth week. The bottom part of this cavity is next converted by adhesion into a sac, which encloses the papilla, whilst its upper portion elongates backwards so as to form another cavity of reserve, in which, at the seventh month after birth, the papilla for the second molar tooth appears. After a long interval, during which the sac of the first permanent molar, and its contained tooth, has acquired great size, (fig. 439,) and that of the second molar has also advanced considerably in development, the same changes once more occur, and give rise to the sac and papilla of the wisdom tooth, the rudiments of which are visible at the sixth year. The subsequent development of the permanent molar teeth takes place from these sacs just like that of the other teeth.

Calcification begins first in the anterior permanent molar teeth. Its order and periods are thus stated for the upper jaw, the lower being a

little earlier. First molar, five or six months; central incisor, soon after; lateral incisor and canine, eight or nine months; two bicuspids, two years and over; second molar, five or six years; third molar, or wisdom tooth, about twelve years.

Eruption of the Permanent Teeth.—The time at which this occurs in regard to each pair of teeth in the lower jaw is exhibited in the subjoined tables, given on the authority of Dr. Blake and Mr. Cartwright. The corresponding teeth of the upper jaw appear somewhat later.

BLAKE.	Years.
Molar, first	$6\frac{1}{2}$
Incisors, central	7
" lateral	8
Bicuspids, anterior	9
" posterior	10
Canines	11 to 12
Molars, second	12 to 13
" third (or wisdom)	17 to 25

CARTWRIGHT.	Years.
Molar, first / Incisors, central inferior	5 to 7
" " superior	6 — 8
" lateral	7 — 9
Bicuspids, anterior	8 — 10
Canines	9 — 12
Bicuspids, posterior	10 — 12
Molars, second	12 — 14
" third (wisdom)	17 — 25

It is just before the shedding of the temporary incisors, *i. e.* about the fifth year, that there is the greatest number of teeth in the jaws. At that period there are all the milk teeth, and all the permanent set except the wisdom teeth, making forty-eight.

During the growth of the teeth the jaw increases in depth and length, and undergoes certain changes in form. In the child it is shallow, (fig. 74,) but it becomes much deeper in the adult, (fig. 73.) In the young subject the alveolar arch describes almost the segment of a circle; but in the adult the curve is semielliptical. The increase which takes place in the length of the jaw arises from a growth behind the position of the milk teeth, so as to provide room for the three additional teeth on each side, belonging to the permanent set. At certain periods in the growth of the jaws there is not sufficient room in the alveolar arch for the growing sacs of the permanent molars; and hence those

Fig. 439.

Part of lower maxilla of a child, containing all the milk teeth of the right side, and the incisors of the left. Sacs and pedicles of the permanent teeth (except the wisdom tooth), exposed by removing part of the bone on the inside. The alveolar canal also laid open to show the course of the nerve. The large sac near the ramus of the jaw is that of the first permanent molar; and above and behind it, is seen the commencing rudiment of the second molar.

parts are found at certain stages of their development to be enclosed in the base of the coronoid process of the lower jaw, (fig. 439,) and in the maxillary tuberosity in the upper jaw, but afterwards successively assume their ultimate position as the bone increases in length. The space taken up by the ten anterior permanent teeth exactly corresponds with that which had been occupied by the ten milk teeth; the difference in width between the incisors of the two sets being compensated for by the smallness of the bicuspids in comparison with the milk molars to which they succeed. Lastly, the angle formed by the ramus and body of the lower jaw differs at different ages; thus it is obtuse in the infant; approaches nearer to a right angle in the adult; and again becomes somewhat obtuse in old age (figs. 73, 74).

Relation of the blood-vessels to the tooth.—There is no evidence that the blood-vessels send branches into the hard substance. The red stain sometimes observed in the teeth, after death by asphyxia, and the red spots otherwise found in the dentine, are due to the imbibition of blood effused on the surface of the pulp. The dentine formed in young animals fed upon madder is tinged with that colouring matter, but this does not appear to take place when the growth of the tooth is completed. Nevertheless the tubules of the dentine may serve to convey through its substance nutrient fluid poured out by the blood-vessels of the pulp. The teeth are sometimes stained yellow in jaundice.

Analogy between teeth and bone.—By the older anatomists the teeth were considered to be identical with bone, and were described as parts of the skeleton. Subsequently to this they were compared to the cuticular tissues, but the revelations of the microscope have tended to re-establish the former opinion.

The enamel is the only part which has no analogy with bone. The crusta petrosa is in all respects similar to bone; and, in regard to the dentine, numerous points of resemblance have been clearly established. Their chemical constituents are the same in nature, although they differ somewhat in their proportions; but the bones themselves vary in this respect at different ages, and even in different parts of the same skeleton.

The tubuli of the dentine and the canaliculi of bone though differing materially in size are suggestive one of the other: the former open on the interior of the pulp cavity, and the latter on the walls of the Haversian canals; they both branch out and anastomose by their finest twigs; and both communicate with minute cells or lacunæ, situate in the surrounding hard substance, which, though very inconspicuous and rare in the human tooth, are large and very evident in the teeth of animals. It happens, moreover, that in the bones of osseous fishes these lacunæ are very few in number.

The pulp cavity of a tooth with its vascular contents, and the Haversian canals of bone with their nutrient vessels, may be justly compared together. If we imagine a section of a group of coalesced teeth, the pulp cavities with their surrounding tubuli would represent a series of Haversian canals with their canaliculi; and in the teeth of the lower animals, as already mentioned, these tubuli are even connected with numerous lacunæ. The inner portion of the tooth of the walrus presents a structure analogous to what is here imagined, inasmuch as the pulp cavity is divided into branches which resemble Haversian canals, and have radiating tubuli proceeding from them. A similar structure is seen in the osteodentine or secondary dentine formed within the human teeth, which thus, it may be remarked, agrees both in nature and position with the core of the walrus tooth. It is stated by Mr. Tomes that in one or two specimens he has seen vascular canals traversing the dentine of the fang of the human tooth, proceeding from the pulp cavity outwards. The mode of growth of teeth and bone is evidently not so different as was formerly supposed, but until the stages of this process in both are

better understood, it would be premature to attempt any minute comparison between them in this respect.

It has been offered as an objection to the assumed analogy, that the teeth, unlike bones, are in part at least uncovered by soft tissues; but true bony structures are sometimes similarly situated, as in the cutaneous plates of the sturgeon or armadillo, and the antlers of the deer.

Vibrios of the mouth.—It may be mentioned here, that in the white sordes surrounding the necks of the teeth, Leeuwenhoek discovered by the microscope numerous minute animalcules of the Vibrio kind which exhibit very active movements, and which are probably produced in such portions of vegetable and animal matters used as food, as happen to adhere between the margin of the gums and the teeth.

More recently Buhlmann has observed fine transparent fibres on the surface of the teeth, especially where tartar had been allowed to gather on them. These fibres were slightly elastic, but consisted of some sort of inorganic substance, probably of a siliceous nature, for they resisted the action of the strongest acids and alkalies.

THE TONGUE.

The *tongue* is the proper organ of taste, and owing to its position in the floor of the mouth, and to its great mobility, it assists in mastication and deglutition, and also in articulation.

In its general form, the tongue is adapted to the interval between the two halves of the lower jaw: thus it is wider, and at the same time thicker, at its *base* or *root*, which is turned backwards, and narrower and thinner at its *apex* or *tip*, which is directed forwards against the inner surface of the lower incisor teeth. The base and the posterior part of the under surface of the tongue are attached; but the fore part of its under surface, the sides or borders, the upper surface and the tip, are free.

The *attachments* of the tongue are partly muscular, or fibro-cellular, and in part consist of reflections of the mucous membrane of the mouth. Thus, it is connected to the soft palate by the palato-glossus muscle, to the styloid process by the stylo-glossus, to the hyoid or *lingual bone* by the hyoglossus and some fibro-cellular tissue, and, lastly, to the inferior maxilla by the genio-hyo-glossus (fig. 444).

By means of the mucous membrane, the tongue is connected behind with the epiglottis; three folds, named the glosso-epiglottic folds or frænula, of which the middle one is the larger, pass backwards from the one to the other (figs. 440, 444). On each side of these, the tongue is connected with the pharynx, and farther outwards with the soft palate, by the two arches or pillars of the fauces (fig. 441, *r*, *i*). Lastly, from the under surface of the tongue, at the sides and also in front, the mucous membrane is reflected over the sublingual gland to the inner surface of the gums of the lower jaw; and it forms in the middle line, in front, a median fold called the *frænum linguæ.*

The *free surface* of the tongue.—The free portion of the under surface of the tongue is covered by a thin and smooth mucous membrane. In front, beneath the tip of the organ, it is marked by a median line continuous with the frænum linguæ. Near this line, on each side, the ranine vein may be distinctly seen through the mucous membrane, and close to it lies the artery of the same name. The ducts of the right and left submaxillary glands also end in the floor of

the mouth, one on each side of the frænum; and further back, in the groove between the sides of the tongue and the lower jaw, are found the orifices of the several ducts belonging to the sublingual glands.

The rounded *borders* of the tongue become gradually thinner in approaching the apex of the organ. The mucous membrane, in passing over them from below, gradually acquires the papillary character of that on the upper surface.

The *upper surface* or *dorsum* of the tongue (fig. 440) is convex in its general outline, and is marked along the middle in its whole length by a slight furrow called the *raphé*,[1] which indicates its bilateral symmetry. About half an inch from the base of the tongue, the raphé often terminates in a depression,[6] closed at the bottom, which is called the *foramen cæcum* (*Morgagni*), and in which several mucous *glands* and follicles open.

The upper surface of the tongue is covered all over with numerous

[Fig. 440.

[Fig. 441.

[Fig. 440. The tongue with its papillæ. 1. The raphé, which in some tongues bifurcates on the dorsum of the organ, as in the figure. 2, 2. The lobes of the tongue. The rounded eminences on this part of the organ, and near its tip are the papillæ fungiformes. The smaller papillæ, among which the former are dispersed, are the papillæ conicæ and filiformes. 3. The tip of the tongue. 4, 4. Its sides, on which are seen the lamellated and fringed papillæ. 5, 5. The V-shaped row of papillæ circumvallatæ. 6. The foramen cæcum. 7. The mucous glands of the roots of the tongue. 8. The epiglottis. 9, 9. The fræna epiglottidis. 10, 10. The greater cornua of the os hyoides.—W.]

[Fig. 441. Various forms of the conical compound papillæ, deprived of their epithelium:—*a*, *b*, and especially *c*, are the best marked, and were provided with the stiffest and longest epithelium; their simple papillæ are more acuminated. *d*, approaches the fungiform variety: *e*, *f*, come near the simple papillæ.—Magnified 20 diameters.—Todd and Bowman.]

projections or eminences named *papillæ*. They are found also upon the tip and free borders, where, however, they gradually become smaller, and disappear towards its under surface. These papillæ are distinguished into three orders, varying both in size and form.

The *large* papillæ (papillæ maximæ, vallatæ, vel circumvallatæ), eight to fifteen in number, ([5] [5],) are found on the back part of the tongue, arranged in two rows, which run obliquely backwards and inwards, and meet towards the foramen cæcum, like the arms of the letter V. They are situated in cup-like cavities or depressions of the mucous membrane, and are shaped like an inverted cone, of which the apex is attached to the bottom of the cavity, and the broad flattened base appears on the surface. They are therefore surrounded, as it were, by a circular furrow or trench, around which again is an

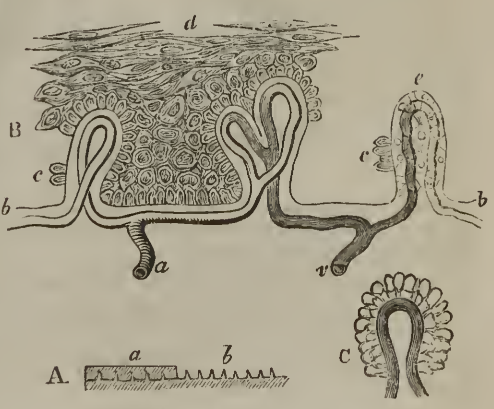
annular elevation of the mucous membrane, covered with the smaller papillæ. The exposed surface of the papillæ vallatæ is beset with numerous smaller papillæ or filaments, and in some of them there is found a central depression into which mucous follicles open.

The *middle-sized* (papillæ mediæ, capitatæ, vel fungiformes), more numerous than the last, are little rounded eminences scattered over the middle and fore part of the dorsum of the tongue; but they are found in greater numbers and closer together near and upon the apex. They are easily distinguished by their more intensely red colour. They are narrow at their point of attachment, but are gradually enlarged towards their free extremities, which are blunt and rounded, and are covered with smaller filamentous appendages or papillæ (fig. 441, *d*).

The *smallest papillæ* (papillæ minimæ), which include the *papillæ conicæ* and *filiformes*, are the most numerous of all. They are minute, conical, tapering, or cylindrical processes, which are densely packed over the greater part of the dorsum of the tongue, towards the base of which they gradually disappear. They are arranged in lines, which correspond at first with the oblique direction of the two ridges of the papillæ vallatæ, but gradually become transverse towards the tip of the tongue. At the sides they are longer and more filiform, and arranged in parallel rows, perpendicular to the border of the tongue. The filiform papillæ are paler and provided with a thicker epithelium than the other kinds; and they are also covered with small and rather stiff secondary papillæ. Interspersed between these three kinds of papillæ, and also at the back part of the tongue behind the papillæ vallatæ, there are found numerous minute projecting filaments, concealed by epithelium, and scarcely visible until that be removed. (Todd and Bowman.)

These different kinds of papillæ are highly vascular and sensitive prolongations of the mucous coat of the tongue. When injected, they seem to consist almost entirely of capillary vessels: the papillæ vallatæ containing many vascular loops, whilst the smallest papillæ (fig. 442) are penetrated by only a single loop. Nerves proceed in abundance to those parts of the tongue which are covered with papillæ, into which the nerve-tubes penetrate. The epithelium covering the papillary surface is of considerable thickness, and

[Fig. 442.



Simple papillæ near the base of the tongue:—A, *a*, concealed under the epithelium; *b*, uncovered by it.—Magnified 10 diameters. B, *a*. Arterial twig, supplying their capillary loops. *v*. Vein. The vessels are all contained within the line *b*, *b*, of basement membrane. *c*, *c*. Deeper epithelial particles resting on the basement membrane. *d*. Scaly epithelium on the surface. The granular interior of the papillæ is represented at *e*. C. Papillæ in which the basement membrane is not visible; and the deep layer of epithelium seems to rest on the capillary loop.—Magnified 200 diameters.—Todd and Bowman.]

belongs to the squamous kind (fig. 442, B, *d*): over the filiform papillæ it is denser than elsewhere, and presents an imbricated arrangement; on some, it forms a lash or pencil of fine fibres; and, on others, it approaches closely in character and structure to hairs (fig. 443). The papillæ are undoubtedly the parts chiefly concerned in the special sense of taste; but they also possess, in a very acute degree, common tactile sensibility; and the filiform papillæ, armed with their denser epithelial covering, serve a mechanical use in the action of the tongue upon the food.

The mucous membrane of the tongue is provided with numerous

[Fig. 443.

A. Vertical section near the middle of the dorsal surface of the tongue:—*a*, *a*. Fungiform papillæ. *b*. Filiform papillæ, with their hair-like processes. *c*. Similar ones deprived of their epithelium.—Magnified 2 diameters.

B. Filiform compound papillæ:—*a*. Artery. *v*. Vein. *c*. Capillary loops of the secondary papillæ. *b*. Line of basement membrane. *d*. Secondary papillæ, deprived of *e*, *e*, the epithelium. *f*. Hair-like processes of epithelium capping the simple papillæ.—Magnified 25 diameters. *g*. Separated nucleated particles of epithelium, magnified 300 diameters.

1, 2. Hairs found on the surface of the tongue. 3, 4, 5. Ends of hair-like epithelial processes, showing varieties in the imbricated arrangement of the particles, but in all a coalescence of the particles towards the point. 5, encloses a soft hair.—Magnified 160 diameters.—Todd and Bowman.]

follicles and glands. The folicles, simple and compound, are scattered over the surface; but the rounded conglomerate glands, called *lingual glands*, are collected about the posterior part of the dorsum of the tongue, near the papillæ vallatæ and foramen cæcum, into which the

ducts of several of these glands open. Other small glands are found also beneath the mucous membrane of the borders of the tongue. There is, in particular, a small group of these glands on the under surface of the tongue near the apex. They are there aggregated into a little oblong mass, out of which several ducts proceed and open separately on the mucous membrane. This little gland, or group of glands, was pointed out by Blandin, and has been more lately described and figured by Nuhn.

The substance of the tongue is chiefly composed of muscular fibres, running in different but determinate directions; hence the variety and regularity of its movements, and its numerous changes of form. Many of the contractile fibres of the tongue belong to muscles which enter at its base and under surface, and attach it to other parts: these, which have been already enumerated, are called the *extrinsic muscles* of the tongue, and have been elsewhere described (vol. i. pp. 353–4, and 366). Other bands of fibres constitute the *intrinsic* or proper muscles, and are arranged in two principal longitudinal layers, with a large intervening mass of transverse fibres.

The first, *superior*, or *superficial* longitudinal layer, named *lingualis superficialis*, is placed on the upper surface of the tongue, immediately beneath the mucous membrane, and is traceable from the apex of the organ backwards to the hyoid bone. The individual fibres do not run the whole of this distance, but are attached at intervals to the submucous and glandular tissues. The entire layer becomes thinner towards the base of the tongue, near which it is overlapped at the sides by a thin plane of oblique or nearly transverse fibres derived from the palato-glossus and hyo-glossus muscles.

The *inferior* or *deep* longitudinal layer of muscular fibres, placed at the under surface of the tongue, is the *lingualis* muscle, properly so called, of Douglas, Albinus, and other anatomists, and is sometimes described as the *lingualis inferior*. It consists of a rounded muscular band, extending along the under surface of the tongue from base to apex, and lying outside the genio-hyo-glossus, between that muscle and the hyo-glossus. Posteriorly, some of its fibres are lost in the substance of the tongue, and others reach the hyoid bone. In front, having first been joined, at the anterior border of the hyo-glossus muscle, by fibres from the stylo-glossus, it is prolonged beneath the border of the tongue as far as its point.

The *transverse* muscular fibres of the tongue (lingualis transversus) form together with the intermixed fat a considerable part of its substance. They are found in the interval between the upper and lower longitudinal muscles, and they intersect extensively with the other muscular fibres. Passing across each way from the median plane of the tongue, they reach its dorsum and borders; and they are considered by some anatomists to take a distinct origin from a median fibrous partition to be presently described. In proceeding outward from the middle line, these transverse fibres have also an inclination upwards, so that they form a series of curves, having the concavity turned upwards. Other transverse fibres, according to Theile, arise from the hyoid bone, between the attachment of the two genio-hyo-glossi

muscles, and run outwards and upwards on each side to reach the border of the tongue. All these fibres intersect, by bundles, the ascending fasciculi of the genio-hyo-glossus and hyo-glossus muscles.

Special vertical fibres have also been described by Gerdy and Cruveilhier as existing in the tongue. Fibres having a vertical direction may undoubtedly be seen on making perpendicular sections of this organ in man; but it is the opinion of Theile, that those seen in a longitudinal vertical section belong to the ascending fasciculi of the genio-hyo-glossus, or hyo-glossus, and the additional vertical fibres which appear in a similar section made transversely belong to the oblique bundles of the transverse system of fibres.

These intrinsic muscles of the tongue serve principally to alter its form, retracting or elongating it in various directions. The superficial longitudinal fibres can also curve the tip of the tongue upwards, and the lower set can curve it downwards. Between the several layers and bundles of muscular fibres, there is always found a considerable quantity of a soft fatty tissue, and also a very fine cellular web.

In the median line, towards the base of the tongue and in the midst of the muscular substance, there is a vertical layer of fibrous tissue, which forms a partial septum between the two halves of the organ. This is connected behind with the hyoid bone; and in front, it is lost between the muscles. It is well known, that, in animals of the dog tribe, a fusiform fibro-cartilage is found in the middle of the tongue near its under surface; and Blandin has described a thin fibro-cartilaginous lamina in the human tongue as forming a part of the vertical median septum, but, according to Krause, in most instances there is no trace of such a structure. The last writer further states, that, when it does exist, it is about three or four lines in height and length; its borders are irregular; its two sides serve as points of insertion to muscular fibres; and it is often imperfect, or pierced with small holes.

The arteries of the tongue are derived from the lingualis, with some small branches from the facial and ascending pharyngeal. The veins for the most part correspond.

The nerves of the tongue (exclusive of branches from the sympathetic nerves) are three: viz., the lingual or *gustatory* branch of the *fifth* pair, which supplies the papillæ and mucous membrane of the fore part and sides of the tongue; the lingual branch of the *glosso-pharyngeal*, which sends filaments to the mucous membrane at the base of the tongue, and especially to the papillæ vallatæ; and, lastly, the *hypoglossal* nerve, which is distributed to the muscles.

THE PALATE.

The roof of the mouth is formed by the palate, which consists of two portions; the fore part being named the hard palate, and the back part, the soft palate.

The osseous framework of the *hard* palate, *a*, fig. 444, the general form and component pieces of which have been described, (vol. i. fig. 156,) covered by the periosteum, and by the lining membrane of the

mouth, which adhere intimately together. The mucous membrane, which is continuous with that of the gums, is thick, dense, rather pale, and much corrugated, especially in front and at the sides; but is

Fig. 444.

Median section of the nose, mouth, pharynx, and larynx.—*a.* Septum of the nose; below it, is the section of the hard palate. *b.* The tongue. *c.* Section of velum pendulum palati. *d, d.* Lips. *u.* Uvula. *r.* Anterior arch or pillar of fauces. *i.* Posterior arch. *t.* Tonsil. *p.* Pharynx. *h.* Hyoid bone. *k.* Thyroid cartilage. *n.* Cricoid cartilage. *s.* Epiglottis. *v.* Glottis. 1. Posterior opening of nares. 3. Isthmus faucium. 4. Superior opening of larynx. 5. Passage into œsophagus. 6. Mouth of right Eustachian tube.

smoother, thinner, and of a deeper colour behind. Along the middle line is a ridge or raphé, ending in front in a small eminence, which corresponds with the lower opening of the anterior palatine canal, and receives the terminal filaments of the naso-palatine and anterior palatine nerves. The membrane of the hard palate is provided with many muciparous glands, which form a continuous layer between the membrane and the bone, and it is covered with a squamous epithelium.

The *soft* palate (velum pendulum palati: *c*) is formed of mucous membrane enclosing muscular fibres and numerous glands. It constitutes an incomplete and movable partition between the mouth and the pharynx. It is attached to the posterior border of the hard palate, the membranous portion of which is thus continued obliquely downwards and backwards. At the sides, the soft palate is also connected with the lining membrane of the mouth and pharynx. Its lower border is free, and has depending from its middle a red conical process called the *uvula*, *u*. From the base of the uvula, on each side, the free margin of the velum forms two arched folds, which pass outwards and then downwards, one behind the other. These are the *anterior and posterior arches of the palate.* The anterior arches, *r*, run downwards and forwards to the sides of the tongue

near its base; whilst the posterior arches, *i*, which approach more closely together, and may therefore be easily seen behind the anterior arches on looking into the throat, run downwards and backwards to the sides of the pharynx. Between the anterior and posterior palatine arch of each side, there is therefore a triangular recess, and in this the corresponding tonsil or amygdala, *t*, is placed. The interval between the palatine arches of the two sides, bounded above by the free margin of the soft palate, and below by the tongue, is the passage leading from the mouth into the pharynx, named the *isthmus faucium*, (before [3],) and the arches are called the *pillars* of the fauces.

The anterior or under surface of the velum, which is visible in the mouth, is concave. The mucous membrane, continuous with that of the hard palate, is thinner and darker than it, and is covered with a scaly epithelium. It is marked by a slight median ridge or raphé, which descends towards the uvula, and indicates the original separation of the velum into two lateral halves.

The posterior surface of the soft palate, slightly convex or arched, is continuous above with the floor of the posterior nares. It is slightly elevated along the middle line, opposite to the uvula. The greater portion of its mucous membrane, as well as that of the free margin of the velum, is covered with a squamous epithelium; but quite at its upper portion, near the orifice of the Eustachian tube,[6] the epithelium is columnar and ciliated.

On both surfaces of the velum are found numerous small glands, called the *palatine* glands. They particularly abound on the upper surface, where they form quite a glandular layer; they are also very abundant in the uvula.

Muscles.—Between the two layers of mucous membrane of which the velum is composed, are situated the muscles of the soft palate. They consist of five muscles on each side;—two superior, viz., the levator palati and the circumflexus or tensor palati; two inferior, viz., the palato-glossus and the palato-pharyngeus,—of which the former is enclosed in the anterior palatine arch, and the latter in the posterior arch; and lastly, one median, which descends into the uvula, and with the muscle of the opposite side forms the azygos uvulæ. The description of these muscles, and of their action, will be found at vol. i. p. 365.

THE TONSILS.

The *tonsils* (tonsillæ, amygdalæ) are two prominent bodies, which occupy the recesses formed, one on each side of the fauces, *t*, between the anterior and posterior palatine arches.

They are usually about six lines in length, and four in width and thickness; but they vary much in size in different individuals.

The outer side of the tonsil is connected with the inner surface of the superior constrictor of the pharynx, and approaches very near to the internal carotid artery. Considered in relation to the surface of the neck, the tonsil corresponds to the angle of the lower jaw, where it may be felt beneath the skin when it is enlarged. Its inner surface, projecting into the fauces between the palatine arches, presents from

twelve to fifteen orifices, which give it a perforated appearance. These orifices lead into recesses in the substance of the tonsil, from which other and smaller orifices conduct still deeper into numerous compound crypts or follicles, the whole being lined with continuations of the buccal mucous membrane. The tonsils therefore consist of groups of compound muciparous crypts. They yield a mucous fluid, which lubricates the fauces. The tonsils receive a very large supply of blood from many sources, viz., from the tonsillar and palatine branches of the facial artery, and from the descending palatine, the ascending pharyngeal and the dorsalis linguæ. Its *veins* are numerous, and enter the tonsillar plexus on its outer side. Its nerves come from the glosso-pharyngeal nerve, and from the fifth pair.

THE SALIVARY GLANDS.

The saliva, which is poured into the mouth, and there mixed with the food during mastication, is secreted by three pairs of glands, named, from their respective situations, the *parotid, submaxillary*, and *sublingual* glands. Agreeing in their general physical characters and minute structure, they differ in their size, form, and position.

The Parotid Gland.

The *parotid gland*, (παρα, and ους, ωτος,) so called from being placed near the ear, is the largest of the three salivary glands. It lies on the side of the face, in front of the ear, and beneath the skin; but it extends deeply into the space behind the ramus of the lower jaw. Its weight varies from five to eight drachms.

Its outer surface is rounded and lobulated, and is covered by the skin and fascia, and partially by the platysma muscle. It is bounded above by the zygoma, below by a line drawn backwards from the lower border of the jaw to the sterno-mastoid muscle, and behind by the external meatus of the ear, the mastoid process, and sterno-mastoid muscle. Its anterior border, which is in contact with the ramus of the lower jaw, is less distinctly defined, and advances forwards to a variable extent on the masseter muscle. It is from this anterior border of the gland that the excretory duct passes off; and there is sometimes found in connexion with the duct, and lying upon the masseter muscle, a small process or a separated portion of the gland, which is called *glandula socia* (*socia parotidis*). On trying to raise the parotid gland from its position, it is found to extend far inwards, between the mastoid process and the ramus of the jaw, towards the base of the skull, and to be intimately connected with several deep-seated parts. Thus, above, it reaches into and occupies the posterior part of the glenoid cavity; behind and below, it touches the digastric muscle, and rests on the styloid process and styloid muscles; and, in front, under cover of the ramus of the jaw, it advances a certain distance between the external and internal pterygoid muscles.

The internal carotid artery and internal jugular vein are close to the inner or deep surface of the gland. The external carotid artery, accompanied by the temporal and internal maxillary veins, passes through the parotid gland, and in that situation gives origin to the

anterior auricular, transverse facial, temporal, and internal maxillary arteries. The gland is also traversed by the facial nerve, which divides within its substance, and by branches of the great auricular nerve.

The *parotid duct*, named also the *Stenonian duct*, appears at the anterior border of the gland, about one finger's breadth below the zygoma, and runs forwards over the masseter muscle, accompanied by the socia parotidis, when that accessory portion of the gland exists, and receiving its ducts. At the anterior border of the masseter, the duct turns inwards through the fat of the cheek and pierces the buccinator muscle; and then, after running for a short distance obliquely forwards beneath the mucous membrane, opens upon the inner surface of the cheek, by a small orifice opposite the crown of the second molar tooth of the upper jaw. Its direction across the face may be indicated by a line drawn from the lower margin of the concha of the ear to midway between the red margin of the lip and the ala of the nose. The length of the Stenonian duct is about two inches and a half, and its thickness about one line and a half. Where it perforates the buccinator, its canal is as large as a crow-quill, but its orifice, which is the smallest part of it, will only admit a very fine probe. The duct is surrounded by cellular tissue, and, besides this, consists of an external dense and thick fibrous coat, in which contractile fibres are described, and of an internal mucous tunic, which is continuous with that of the mouth, but which is covered, from the orifice of the duct as far as to the smallest branches, with a columnar epithelium.

The parotid gland belongs to the class of compound cellular glands, and consists of numerous flattened lobes, held together by the ducts and vessels, and by a dense cellular web, which is continuous with the fascia upon its outer surface; but the gland has no special or proper coat. The lobes are again divided into lobules, each of which consists of the branched terminations of the duct, and of vessels, nerves, and fine cellular tissue. The ducts terminate in closed vesicular extremities, about $\frac{1}{1200}$th of an inch or more in diameter, and having capillary vessels ramifying upon them.

The vessels of the parotid gland enter and leave it at all points. The arteries are derived directly from the external carotid, and from those of its branches which pass through or near the gland. The veins correspond. The absorbents join the deep and superficial set in the neck; and there are often one or more lymphatic glands embedded in the substance of the parotid. The nerves come from the sympathetic (carotid plexus,) and also, it is said, from the facial and the superficial temporal and great auricular nerves.

The Submaxillary Gland.

The *submaxillary gland*, the next in size to the parotid gland, is of a rounded form, and weighs about 2 or 2½ drachms. It is situated immediately below the base and the inner surface of the inferior maxilla, and above the digastric muscle. In this position it is covered in by the skin and the platysma myoides, and its inner surface rests on

the mylo-hyoid, hyoglossus, and stylo-glossus muscles; above, it corresponds with a depression on the inner surface of the jaw-bone; and it is separated behind from the parotid gland, merely by the stylo-maxillary membrane. The facial artery, just before it mounts over the jaw-bone, lies in a groove upon the back part and the upper border of the gland.

The *duct* of the submaxillary gland, named the *Whartonian duct*, which is about two inches in length, passes off from the gland, together with a thin process of the glandular substance, around the posterior border of the mylo-hyoid muscle, and then runs forwards and inwards above that muscle, between it and the hyoglossus and genio-hyoglossus, and beneath the sublingual gland, to reach the side of the frænum linguæ. Here it terminates, close to the duct of the opposite side, by a narrow orifice, which opens at the summit of a small caruncle seen beneath the tongue. The structure of this gland is like that of the parotid; but its lobes are larger, its surrounding cellular web is finer, and its attachments are not so firm. Moreover, its duct has much thinner coats than the parotid duct.

Its blood-vessels are branches of the facial and lingual arteries and veins. The nerves include those derived from the small submaxillary ganglion, as well as branches from the myloid division of the inferior dental nerve, and the sympathetic.

The Sublingual Gland.

The *sublingual gland*, the smallest of the salivary glands, is of a narrow oblong shape, and weighs scarcely one drachm. It is situated along the floor of the mouth, where it forms a ridge between the tongue and the gums of the lower jaw, covered only by the mucous membrane. It reaches from the frænum linguæ, in front, where it is in contact with the gland of the opposite side, obliquely backwards and outwards for rather more than $1\frac{1}{2}$ inch. On its inner side it rests on the genio-hyoglossus; beneath, it is supported by the mylo-hyoid muscle, which is interposed between it and the submaxillary gland; but it is here in close contact with the Whartonian duct, with the accompanying deep portion of the last-named gland, and also with the lingual nerve.

The lobules of the sublingual gland are not so closely united together as those of the other salivary glands, and the ducts from many of them open separately into the mouth, along the ridge which indicates the the position of the gland. These ducts, named *ductus Riviniani*, are from eight to twenty in number. Some of them open into the duct of Wharton. One, longer than the rest, (which is occasionally derived in part also from the submaxillary gland,) runs along the Whartonian duct, and opens either with it or very near it; this has been named the duct of Bartholine.

The sublingual and submental arteries and veins supply this small gland. The nerves are numerous, and are derived from the lingual branch of the fifth pair.

Saliva.—The saliva secreted by these glands is a clear limpid fluid, containing a few microscopic granular corpuscles. Its specific gra-

vity is 1·006 to 1·008, and it has only about 1 to 1½ parts of solid matter in 100. It is always alkaline during the act of mastication; but afterwards becomes acid, and remains so until the next time of taking food. Its chief ingredients, besides water and mucus, are a peculiar animal extractive substance, named salivine, with some alkaline and earthy salts. It is remarkable, besides, for containing a minute proportion of sulphocyanide of potassium.

Development.—In mammalia, according to Müller and Weber, the salivary glands, as shown in the case of the parotid gland in the embryo of the sheep, (fig. 445.) first appear in the form of a simple canal with bud-like processes lying in a blastema, and communicating with the cavity of the mouth. This canal becomes more and more ramified to form the ducts, whilst the blastema soon

Fig. 445.

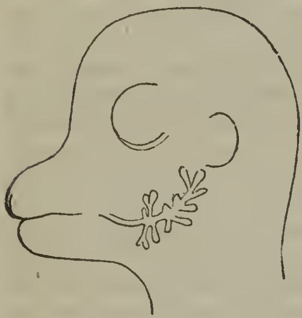


Fig. 446.

Fig. 445. Early appearance of the parotid gland in the embryo of the sheep. (Müller.)

Fig. 446. Lobules of the parotid gland, in the embryo of the sheep, in a more advanced condition. (Müller.)

acquires a lobulated form (fig. 446), corresponding with that of the future gland, and at last wholly disappears, leaving the branched ducts, with their blood-vessels and connecting tissues. The submaxillary is said to be the first formed; then the sublingual and the parotid.

THE PHARYNX.

The pharynx (fig. 444, p,[5]) is that part of the alimentary canal which intervenes between the cavity of the mouth and the œsophagus. It is situated behind the nose, mouth, and larynx, in front of the vertebral column, and between the great vessels of the neck; reaching from beneath the basilar process of the occipital bone down to the level of the cricoid cartilage, opposite the fifth cervical vertebra, where it ends in the œsophagus.

It forms an oblong sac, open at the lower end, and imperfect in front, where it presents apertures leading into the nose, mouth, and larynx, but closed in other directions, viz., above, behind, and at the

sides. The walls of this sac consist of a fascia or layer of fibrous tissue, dense at its upper part, but lax and weak below, surrounded by muscles, and lined by a mucous membrane. Its upper end forms a *cul-de-sac* beneath the basilar process, to which and also to the petrous portion of the temporal bone it is attached by a tendinous expansion, which descends some distance on its posterior and lateral surfaces. Behind, it is loosely connected by cellular tissue to the prævertebral fascia covering the bodies of the cervical vertebræ and the muscles which rest upon them. At the side it has similar connexions, by loose cellular tissue, with the styloid process and its muscles, and with the large vessels and nerves of the neck. In front, the walls of the pharynx are attached in succession to the sides of the posterior nares, the mouth, and the larynx. Thus, commencing above by a tendinous structure only, at the petrous portion of the temporal bone and the Eustachian tube, its walls are connected by means of muscle and fibrous membrane, first, with the internal pterygoid plate, then with the pterygo-maxillary ligament, and next with the mylo-hyoid ridge of the lower jaw: below this, again, they are attached to the sides of the tongue, to the hyoid bone, and stylo-hyoid ligament; and lastly, to the thyroid and cricoid cartilages.

The pharynx is about four inches and a half in length, and is somewhat wider across than it is deep from before backwards. Its width above is moderate; its widest part is opposite the cornua of the hyoid bone, and below this it rapidly contracts towards its termination, opposite the cricoid cartilage, which is the narrowest part.

The velum pendulum palati projects backwards into the pharynx, and during the passage of the food is applied to its posterior wall. Seven openings lead into the cavity of the pharynx; viz., above the velum the two posterior openings of the nares (1), and at the sides the apertures of the Eustachian tubes (6); below the velum there is first the passage leading from the mouth (3), then the superior opening of the larynx (4), and, lastly, the passage into the œsophagus (5).

Structure.—The *muscles* of the pharynx are the superior, middle, and inferior constrictors, the stylo-pharyngeus, and the palato-pharyngeus (vol. i. pp. 361, 366). At the upper end of the pharynx, its structure is strengthened by a firm dense fascia, already referred to, named the pharyngeal aponeurosis, which is attached above to the basilar process, and, at the sides, to the petrous portion of the temporal bones. It diminishes in thickness as it descends.

The *mucous* membrane lining the inner surface of the pharynx is continuous at the several apertures with that of the adjacent cavities. It varies somewhat in its character in different parts. Its upper portion is thick where it adheres to the periosteum of the basilar process, but is much thinner near the entrance of the Eustachian tube and the posterior nares: in this situation numerous *glands* are found collected in a layer beneath the mucous membrane. In the part opposite the fauces, the mucous membrane exactly resembles that of the mouth, and is provided with glands. Lower down it becomes paler, and at the back of the larynx it forms several longitudinal folds or plicæ. According to Henlé, the epithelium upon the upper portion of the

pharynx, as low down as a horizontal line level with the floor of the nares, is columnar and ciliated; but, below that point, is squamous and destitute of cilia.

THE ŒSOPHAGUS.

The *œsophagus* or gullet is a membranous tube leading from the pharynx to the stomach, and forming the passage through which the food descends into the latter organ. It commences at the cricoid cartilage, (fig. 444,[5]) opposite the fifth cervical vertebra, and, descending along the front of the spine, passes through the diaphragm opposite the ninth dorsal vertebra, and then ends by opening into the cardiac orifice of the stomach (fig. 448,[2]).

The length of the œsophagus is about nine inches. The diameter of its passage is less than that of any other division of the alimentary canal, its smallest part being at the commencement behind the cricoid cartilage; it is also constricted in passing through the diaphragm, but, below that, gradually widens into the stomach; [it very gradually increases in width to the constriction at the passage through the diaphragm.] The œsophagus is nearly straight in its direction, having only two or three slight curvatures. Of these, one corresponds with the antero-posterior flexure of the vertebral column in the neck and thorax. It also has two slight lateral bendings, for though at its commencement it is placed upon the median line, yet, towards the root of the neck, it inclines to the left side; from thence to the fifth dorsal vertebra it gradually resumes its position towards the middle line, and, finally, it deviates again to the left, at the same time coming forward towards the œsophageal opening of the diaphragm. The œsophagus is for the most part applied to the anterior surface of the spine, being connected with it and with the longus colli muscle by loose cellular tissue: the thoracic duct ascends obliquely from right to left, between it and the bodies of the upper dorsal vertebræ, and towards its lower extremity it is placed in front of the aorta. In the *neck*, the œsophagus lies immediately behind the trachea; on each side of it is the common carotid artery, and also a part of the thyroid body, but, as it inclines to the left side, it is in more immediate connexion with the left carotid; the recurrent laryngeal nerves ascend between the œsophagus and trachea. In the *thorax*, the gullet is covered in front by the lower part of the trachea, by the commencement of the left bronchus, and by the back of the pericardium. The aorta, except near the diaphragm, where the œsophagus is in front of the vessel, lies rather to the left, and the vena azygos to the right; the pneumogastric nerves descend in close contact with its sides, and form a plexus around it, the left nerve coming down gradually in front, and the right nerve retiring behind it. Lastly, the œsophagus, which is here placed in the interval between the two pleuræ, receives a partial covering on each side from those membranes.

The walls of the œsophagus are composed of three coats; viz., an external or muscular, a middle or cellular, and an internal or mucous coat.

The *muscular* coat consists of two layers of fibres, disposed in different planes, and taking opposite directions; these are an *external* longitudinal layer, and an *internal* circular layer. This two-

fold arrangement of the muscular fibres of the alimentary canal prevails throughout its whole length; but the two layers are here much thicker, more uniformly disposed, and more evident than elsewhere, except quite at the lower end of the rectum. The external or *longitudinal* fibres are disposed at the commencement of the tube in three fasciculi, seen one in front, and one on each side of the œsophagus. The lateral bundles are blended above with the inferior constrictor of the pharynx; the anterior fasciculus arises from the back of the cricoid cartilage, at the prominent ridge between the crico-arytenoid muscles, and then spreads out obliquely on each side of the gullet as it descends, and soon blends with the lateral bundles to form a continuous layer around the tube. The internal or *circular* fibres are continuous above with those of the inferior constrictor of the pharynx. The rings or circles which they form around the tube have a transverse direction at the upper and lower part of the œsophagus, but in the intervening space are somewhat oblique. At the lower end of the œsophagus, both layers of fibres become continuous with those of the stomach.

The muscular coat of the upper end of the œsophagus is red, and consists of the striped muscular fibres; but lower down it becomes paler, and is principally composed of the plain muscular fibres. A few striped fibres, however, are found mixed with the others, and have been traced throughout its whole length, and even, it is said, upon the cardiac end of the stomach. (Ficinus.)

The *cellular* coat is placed between the muscular and mucous coats, and connects them together but very loosely.

The *mucous membrane* is of firm texture, and is paler in colour than that of the pharynx or stomach. From its loose connexions its outer surface is freely movable on the muscular tunic; and when the latter is contracted and the œsophagus is shut, as happens when it is not giving passage to food, the sides of the tube are in mutual contact. In this state, the mucous membrane is thrown into longitudinal folds, which disappear on distension of the canal.

Minute papillæ are seen upon this mucous membrane, placed at some distance from each other; and the whole is covered with a thick squamous epithelium, which can be traced as far as the cardiac orifice of the stomach, where it suddenly changes its character, as will be hereafter noticed.

The gullet is provided with many small compound glands, named *œsophageal glands*, which are especially numerous at the lower end of the tube.

THE ABDOMINAL PORTION OF THE DIGESTIVE ORGANS.

That part of the digestive canal which is found beneath the diaphragm, and consists of the stomach and intestines, is situated within the cavity of the *abdomen*, the extent, boundaries, and regions of which may here be briefly explained.

THE ABDOMEN.

The abdomen (*abdere*, to conceal) is the largest cavity in the body,

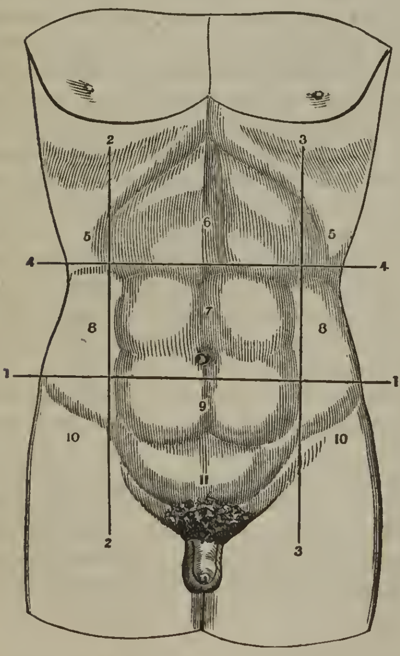
and is lined by an extensive and complicated serous membrane, named the peritoneum.

Including the cavity of the pelvis, which in fact constitutes its lower part, it extends from the diaphragm above to the levatores ani muscles below; and from the transversales muscles in front, to the spine, the quadrati lumborum, and iliaci muscles behind. All of these structures, excepting the diaphragm and spine, are lined with a fibrous layer or *fascia*, which is differently named according to the parts to which it is attached. Through these several structures, which taken together constitute the walls of the abdomen, several apertures exist for the transmission of vessels or other organs into and out of the cavity. Thus, superiorly, there are three principal apertures in the diaphragm, for the passage of the aorta, the vena cava, and the œsophagus. In front, there is the umbilicus, which is pervious during fœtal life, and then transmits the umbilical vessels. Lower down, there is an opening on each side for the femoral vessels, and a second on each side for the spermatic cord in the male, and the round ligament of the uterus in the female. In the pelvic portion of this great cavity there is an opening for the termination or outlet of the intestinal canal, and another for that of the genito-urinary passages. To these may be added several smaller openings for blood-vessels and nerves.

The cavity, as above defined, contains the greater part of the digestive organs, the urinary organs, and the internal organs of generation. It is subdivided into two parts: an upper and larger part, the *abdomen*, properly so called; and a lower part, named the *pelvic cavity*. The limits between the abdominal and pelvic portions of the cavity are marked by the brim of the pelvis.

For the purpose of enabling precise reference to be made to the situation and condition of the contained organs, the *abdomen proper* has been artificially subdivided into certain regions, the boundaries of which are indicated by lines drawn upon the surface of the body. Thus, two transverse lines drawn round

Fig. 447.

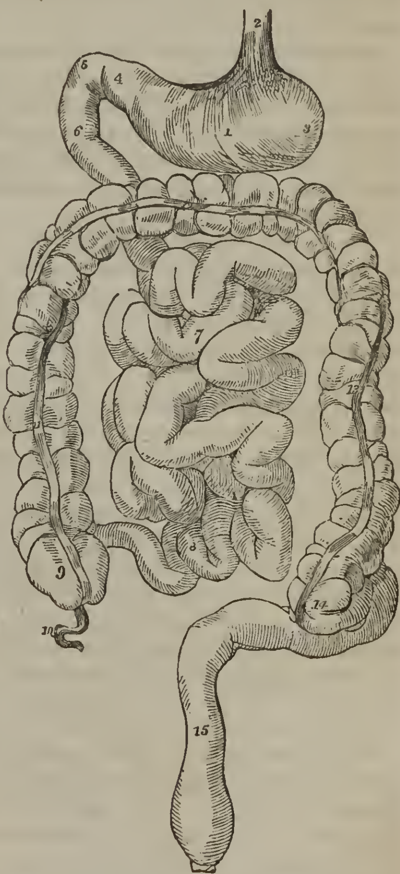


Surface of the abdomen, with lines (1, 2, 3, 4) drawn upon it, marking off its artificial subdivisions into regions 5, 5. Right and left hypochondriac. 6. Epigastric region. 7. Umbilical. 8, 8. The two lumbar. 9. Hypogastric. 10, 10. The right and left iliac regions. 11. Regio pubis.

the body divide it into three zones; viz., an upper, a middle, and a lower. One of these transverse lines, commencing at the most prominent point of the costal cartilages at one side, is drawn across to the corresponding point on the opposite side, and thence round the back to the place at which it began. The other line, proceeding from the crest of the ilium at one side, extends to that of the other, and so round the body, as in the former instance. These zones are further subdivided into three parts by means of two perpendicular lines, drawn from the cartilage of the eighth rib, at each side, down to the centre of Poupart's ligament.

The upper zone is thus marked off into the right and left *hypochondriac* (ὑπο, under; χονδρος, the cartilage) *regions* (fig. 447, [4 4]), and the *epigastric* (επι, upon; γαστηρ, the stomach) region ([1]), which is sometimes called *scrobiculus cordis*. The middle zone is divided into the *umbilical* region in the centre ([2]), and the right and left *lumbar* regions ([5 5]); and the inferior zone into the *hypogastric* or *pubic* region ([3]), in the centre, and the *iliac* region at each side ([6 6]).

Fig. 448.



Now the subdiaphragmatic or abdominal portion of the alimentary canal, and its several accessory viscera, occupy nearly the whole of the cavity of the abdomen,—the urinary organs, and some part of the organs of generation taking up but a very limited space within it.

This part of the digestive tube is subdivided into the stomach, (fig. 448,[1]), the small intestine,[7] and the great intestine ([13]), distinctions which are founded on evident differences of form and structure. The small intestine is further distinguished by anatomists into three parts, named the *duodenum* ([6]), the *jejunum* ([7]), and the *ileum* ([8]). The large intestine, also, is distinguished into the *cæcum* ([9]), the *colon* ([11, 14]), and the *rectum* ([15]). Moreover, the colon itself is named, in its different parts, the *ascending* ([11]), *transverse* ([12]), and *descending* ([13])

Fig. 448. Diagram of the stomach and intestines, to show their course. 1. Stomach. 2. Œsophagus. 3. Left, and 4, Right end of stomach. 5, 6. Duodenum. 7. Convolutions of jejunum. 8. Those of ileum. 9. Cæcum. 10. Vermiform appendix. 11. Ascending, 12. Transverse; and 13. Descending colon. 14. Commencement of sigmoid flexure. 15. Rectum.

colon; and at its lower part, presents a remarkable bend, called the *sigmoid flexure* ([14]).

On opening the abdomen, from the front, these several parts, and also the viscera appended to them, are seen to be more or less covered by the general lining membrane of the cavity, named the peritoneum; and are found to be attached to its posterior and upper walls, by means of folds or duplicatures of that membrane, which include the blood-vessels, nerves, and lymphatics belonging to each organ.

A general idea of the position and arrangement of the abdominal viscera may be obtained by referring them to the transverse colon. This portion of the large intestine crosses through the abdomen from right to left, immediately behind the anterior wall, a little above the umbilicus. Together with the peritoneal fold, called the transverse mesocolon, by which it is attached behind, the transverse colon divides the abdominal cavity into two parts, one being above and the other below it.

Above it, are found the liver, with its excretory apparatus, which occupies the right hypochondrium, a part of the epigastrium, and extends a short way into the left hypochondrium; the stomach, which lies in the epigastric and left hypochondriac regions; the spleen, which is closely applied to the left end of the stomach; and, lastly, the commencement of the duodenum, which is continuous with the right end of the stomach.

Below the transverse colon, and covered by a process of the peritoneum, containing fat, and called the great omentum, are found the convolutions of the jejunum and ileum, attached by the mesentery. These convolutions occupy the umbilical and hypogastric regions, and are surrounded by the large intestine, which occupies the iliac and lumbar regions on each side, and crosses the upper part of the umbilical region, as already mentioned. On lifting up the transverse colon, with its mesocolon, the termination of the duodenum is seen passing under it; and, placed across the spine at the root of the mesocolon, and above the last portion of the duodenum, is found the pancreas. The rectum, or lower part of the large intestine, passes down into the pelvic cavity.

On removing the digestive organs from the abdomen, the kidneys, supra-renal capsules, and ureters, the great blood-vessels, lymphatics and nerves, are found lying quite at the back of that cavity. The bladder when full, and the uterus in its gravid state, project upwards into the abdomen, and displace the small intestine.

THE STOMACH.

The stomach (fig. 448,[1]; γαστηρ) is that dilated portion of the alimentary canal which intervenes between the œsophagus and the duodenum, and within which the food is to be retained to be acted on by the gastric juice, and to be converted into chyme.

This organ is seated in the left hypochondriac and the epigastric regions, and in a part also of the right hypochondrium. It is placed across behind the anterior wall of the abdomen, beneath the liver and diaphragm, and above the transverse colon.

The stomach, when distended, has the shape of an irregular cone having a rounded base and being curved upon itself. The left extremity ([3]) is the larger, and is named the *great* or *splenic* end of the stomach. The *right* or *small* end ([4]) is also named the *pyloric* extremity. Of its two orifices, the one by which food enters from the œsophagus is named the *cardiac* orifice (fig. 449, *o*), the other, by which the stomach communicates with the duodenum, and which is placed on a little lower level, and more forwards, is the *pyloric* orifice (*q*).

The œsophagus terminates in the stomach two or three inches from the great extremity, which projects beyond that tube to the left, and is named the *great cul-de-sac* or *fundus* (*c*).

Between the cardiac and the pyloric orifices, the outline of the stomach is curved along its upper and lower borders. The upper border, about three inches in length, is concave, and is named the *lesser curvature* (*b*); while the lower border, which is much longer, and, except towards the pylorus, convex, forms the *greater* curvature (*a*). These two borders or curvatures constitute the limits between the *anterior* and the *posterior* surfaces of the organ.

Towards the pylorus (*q*), the small end of the stomach describes a double bend, opposite to the first turn of which is a prominence or bulging, sometimes named the *small cul-de-sac* or *antrum pylori* (*d*).

Dimensions.—These vary greatly according to the state of distension of the organ. When moderately filled, its length is about ten or twelve inches; and its diameter, at the widest part, from four inches to four inches and a half. According to Clendinning, it weighs, when freed from other parts, about four ounces and a half in the male, and somewhat less in the female.

Connexions.—The stomach is in contact with many surrounding parts, to several of which it is attached in different ways.

Fig. 449.

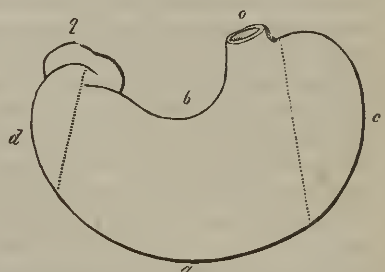


Diagram outline of stomach.—*a*. Great curvature. *b*. Lesser curvature. *c*. Left end, great cul-de-sac or fundus. *d*. Small cul-de-sac or antrum pylori. *o*. Œsophageal orifice or cardia. *p*. Duodenal orifice or pylorus.

Its anterior and posterior surfaces are free, smooth, and covered with peritoneum. The anterior surface, which is directed slightly upwards as well as forwards, is in contact above with the diaphragm and the under surface of the liver, and lower down with the abdominal parietes opposite to the epigastric region, which is hence named the *pit* of the *stomach*. The posterior surface is turned downwards and backwards, and rests upon the transverse meso-colon, and further back, upon the pancreas and great vessels of the abdomen.

At its cardiac orifice it is continuous with the œsophagus, and is, therefore, fixed to the œsophageal opening in the diaphragm, being also connected with that muscle by a reflection of the peritoneum, sometimes named the *gastro-phrenic ligament*. This is, therefore, the

most fixed part of the stomach, and is placed higher, and at the same time further back, than any other part of the organ. The pyloric extremity, situated lower down, nearer to the surface, and having greater freedom of motion, is continuous with the duodenum. It is covered by the concave surface of the liver, and, in some cases, touches the neck of the gall-bladder. The lesser curvature, which is turned upwards and backwards, is connected by means of a fold of the peritoneum, named the lesser or *gastro-hepatic omentum*, with the under surface of the liver. From the greater curvature of the stomach proceeds another double layer of peritoneum, loaded with fat, which is called the great or *gastro-colic omentum*. The duplicature of peritoneum forming the gastro-hepatic omentum, having reached the lesser curvature of the stomach, separates into its two layers, of which one passes over the anterior surface, and the other upon the posterior surface of the organ, as far as to its greater curvature: here they again become applied to one another, and, leaving the stomach, pass down in front of the small intestine, and form the great omentum, which, again turning upwards, becomes attached to the transverse colon. The blood-vessels and lymphatics of the stomach pass within these duplicatures of the peritoneum, and reach the organ along its two curvatures. Lastly, the great cul-de-sac is in contact partly with the diaphragm, but chiefly with the concave surface of the spleen, with which it is connected by means of a fold of peritoneum, named the *gastro-splenic omentum*, and by its contained vessels.

When the stomach is distended, its position and direction are changed. The œsophageal end being fixed to the back part of the diaphragm cannot alter much, but the duodenal extremity has more liberty of motion. The lesser curvature is, also, tolerably well fixed to the liver by the small omentum, while the great curvature is the most movable part: accordingly, when the stomach is distended, this curvature is elevated and at the same time carried forwards, whilst the anterior surface is turned upwards and the posterior surface downwards.

Structure.—The walls of the stomach consist of four distinct coats, held together by fine cellular tissue. They are named, in order from within outwards, the serous, muscular, cellular, and mucous coats. By some the cellular coat is not reckoned as a separate tunic. Taking all the coats together, the walls of the stomach are thinner than those of the œsophagus, but rather thicker than those of the intestines generally. They are thickest at the pyloric end, and thinnest in the great cul-de-sac.

The *external* or *serous* coat, derived from the peritoneum, is a thin, smooth, transparent, and elastic membrane, which covers the entire viscus, excepting along its two curvatures, from which, as already mentioned, it is reflected so as to form the small and great omenta. Along the place of this reflection, between the borders of the stomach and the two layers of the peritoneum, is a three-sided space, occupied by loose cellular tissue, and containing the larger blood-vessels and lymphatics of the organ, which, in this way, reach and run along the two curvatures. The existence of this space, and the loose nature of

the attachment of the peritoneal tunic in its neighbourhood, must facilitate the alternate distension and collapse of the stomach. In other situations, the serous coat adheres firmly to the muscular coat.

The second, or *muscular* coat is composed of three sets of fibres, named from their direction, the longitudinal, the circular, and the oblique fibres, which form three layers.

The first or outermost layer consists of the *longitudinal* fibres, which are, in fact, a continuation of those of the œsophagus. They spread out in a radiating manner from the cardiac orifice, for which reason they are sometimes called the *stellate* fibres, and are found in greatest abundance along the curvatures, especially on the lesser one. On the anterior and posterior surfaces they are very thinly scattered, or are not to be found at all. Towards the pylorus they are arranged more closely together and form a thicker uniform layer, which becomes continuous with the longitudinal fibres of the duodenum.

The second set are the *circular* fibres, which form a complete layer over the whole extent of the stomach. They commence by small and thinly scattered rings at the left extremity of the great cul-de-sac, describe larger and larger circles as they surround the body of the stomach, and towards the pyloric end again form smaller rings and at the same time become much thicker and stronger than at any other point. At the pylorus itself, they are gathered into an annular bundle, which projects inwards into the cavity and forms, together with a covering of mucous membrane, the pyloric sphincter.

The innermost muscular layer is incomplete, and consists of the *oblique* fibres. These oblique fibres are continuous with the circular fibres of the gullet; they embrace the cardiac orifice on the left, where they form a considerable stratum, and from that point descend obliquely upon the anterior and posterior surfaces of the stomach, where they spread out from one another and gradually disappear. They are best seen from the inside of the stomach, after removing the mucous membrane.

The muscular fibres are of a pale reddish colour. They belong to the class of plain fibres, but amongst them, however, Ficinus and Valentin have found some connected with the longitudinal layer which are indistinctly striated.

The *cellular*, or fibrous coat of the stomach is a tolerably distinct layer placed between the muscular and mucous coats, and connected with both. It has also been named from its position the *submucous* coat, and from its white colour, the *nervous* tunic; but it consists essentially of a dense filamentous areolar tissue. It serves to support the mucous coat, and also forms a layer in which the blood-vessels ramify before they enter that membrane: hence it is sometimes called the *vascular* coat. This is not the only cellular layer in the walls of the stomach, for one may be demonstrated between the muscular and serous coats, serving to connect them together, but it is very fine and is not described as a separate tunic.

The internal or *mucous* coat is a smooth, soft, rather thick and pulpy membrane, which has generally a palish pink hue owing to the blood in its capillary vessels, but which, after it has been well washed,

is of a grayish white or pale straw colour. In some cases, however, it presents this pale aspect without any previous washing. In infancy the vascular redness is more marked, the surface having then a rosy hue, but it becomes paler in childhood, and in aged persons is often of an ash-gray colour. During digestion its vessels become congested, and when examined in that condition it is always much darker than usual.

After death a few hours will often suffice to change its colour to a dirty brown tint, mottled and streaked in some cases with dull red lines, corresponding with the course of the veins. This alteration is owing to the exudation of the colouring matter of the blood, and is especially met with in old subjects, in whom the mucous membrane is always thin. In acute inflammation, or after the introduction of irritating substances or of strong acrid poisons, it becomes of a bright red, either all over or in spots, patches or streaks of variable sizes. Corrosive poisons, the gastric juice, and sometimes regurgitating bile, may stain it variously black, brown, yellow, or green; and the effect of chronic inflammation is to leave the membrane of a slate-gray colour.

Independently of all these modifying circumstances connected with the stomach itself, as was pointed out by Dr. Yelloly and others, the colour of the gastric mucous surface is liable to be influenced by causes of a more general nature. Thus, it has been found that in cases of obstructed venous circulation, as when death occurs from hanging or from drowning, and also in certain diseases of the heart, the internal surface of the stomach is reddened to a greater or less extent; but the amount of vascularity may vary from circumstances which are not well understood, and may be found greatly increased in cases in which none of those already named exist.

The gastric mucous membrane is thickest in the pyloric portion of the stomach, and thinnest in the great cul-de-sac. It always becomes thinner in old age.

The outer or *adherent* surface of the mucous membrane is connected with the muscular coat so loosely as to be movable upon it. In consequence of this, and of the great extent and want of elasticity of the mucous membrane as compared with the other coats, the internal surface of the stomach, when that organ is in a contracted state, is thrown into numerous convoluted ridges, *rugæ*, which are produced by the puckering of the mucous, accompanied by the cellular coat, and are entirely obliterated by distension of the stomach. These folds of the mucous coat are most evident along the great curvature, and have a general longitudinal direction.

On examining the gastric mucous membrane closely with the aid of a simple lens, it is seen to be marked throughout, but more plainly towards the pyloric extremity, with little depressions or cells named *alveoli*, (fig. 450,) which have a polygonal figure, and vary from about $\frac{1}{200}$th to $\frac{1}{100}$th of an inch across, being larger and more oblong near the pylorus.

Towards the pyloric region of the stomach, where the mucous membrane is thicker than elsewhere, the margins of these alveoli are elevated into pointed processes, which may be compared to rudimentary *villi*, the perfect forms of those appendages existing only in the small intestine, and making their appearance in the duodenum, immediately beyond the pylorus.

At the bottom of the alveoli or pits above described, and also in the intervals between them, are seen small round apertures, which are the

mouths of minute tubes, placed perpendicularly to the surface, closed at their attached or deep extremity, which rests on the submucous cellular tissue, and opening at the other on the inner surface of the stomach. On making a vertical section of the membrane, and submitting it to the microscope, it is seen to consist almost entirely of these small *tubuli*, arranged close to, and parallel with each other (fig. 451). Their diameter varies from $\frac{1}{500}$th to $\frac{1}{360}$th of an inch, and their length from $\frac{1}{60}$th to $\frac{1}{20}$th of an inch. At the cardiac end of the stomach, where the membrane is thinnest, they are shorter and are simply tubular; but, in approaching the pyloric portion, they gradually become longer and assume a more complicated form, for though quite straight near their orifices, they are convoluted or irregularly sacculated towards their deep or closed extremity. These characters are most perfect near the pylorus. Sometimes two or more of these compound tubuli unite, and open by a single orifice. They exist at all parts of the stomach, even where the alveoli are indistinct or absent; they contain a colourless fluid, with granular matter, and appear to be the secreting organs of the gastric juice. They are formed of a simple homogeneous membrane, lined by a columnar epithelium (fig. 452), which becomes spheroidal towards their closed extremity.

Fig. 450.

Fig. 451.

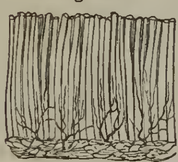


Fig. 452.

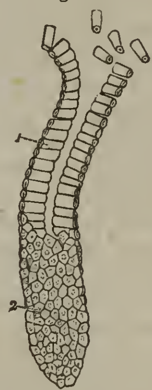


Fig. 450. View of the cells of the mucous membrane of the human stomach, magnified thirty-two diameters. After Dr. Sprott Boyd. The hexagonal cells with their intermediate elevated margins, and the mouths of the tubuli at the bottom of each, are shown.

Fig. 451. Section of the mucous membrane of the stomach of the pig, made perpendicular to the surface, showing the tubuli; the blood-vessels in the submucous cellular tissue are injected. Magnified about twenty diameters. (Boyd.)

Fig. 452. One of the tubuli from the stomach of the pig. It is cut obliquely, and shows the columnar epithelium with which it is lined; at the lower part the outer or attached ends of the columnar particles are seen, with their contained nucleus. After Wasmann.

In some cases, much more evidently than in others, the surface of the mucous membrane in the pyloric portion of the stomach, and also along the adjacent part of the great curvature, presents to the naked eye numerous rounded and whitish eminences, surrounded by slight circular furrows. Cruveilhier suggests that the term granular or glandular might be applied to stomachs having this appearance. The eminences in question have been carefully examined by Bischoff, who

states that they have no peculiar structure, and are merely thicker portions of the mucous membrane. But although a finely mammillated or convoluted appearance (somewhat like the surface of the brain represented in miniature) of the mucous membrane of the stomach may be caused by simple elevations which are not glandular, this membrane is nevertheless provided with lenticular follicles, which when unusually prominent give rise to an appearance similar to that above described. These follicles are marked with a depression in the centre, and are found in greater or less numbers all over the stomach, but are most numerous towards the pylorus. They are best seen in the stomachs of infants and children. Around the cardiac orifice they assume the character of multilocular crypts.

The mucous membrane of the stomach is covered with an epithelium, so thin, however, that its existence was long doubted by anatomists, who conceived that the epithelial layer ceased at the festooned border of the œsophageal mucous membrane. A distinct epithelium exists all over the stomach, covering the margins and floors of the alveoli, and lining the tubuli also (fig. 452). It for the most part belongs to the columnar variety, alternating in some parts with the squamous, which is composed of very minute polygonal scales.

Vessels and nerves.—The stomach is a highly vascular organ. Its *arterial* branches, derived from all three divisions of the cœliac axis, reach the stomach between the folds of the peritoneum, and form, by anastomosing together, two principal arterial arches, which are placed along its two curvatures. That situated along the lesser curvature is formed by the union of the coronary artery and the pyloric branch of the hepatic artery; while the one found at the great curvature is formed by the junction of the right gastro-epiploic branch from the hepatic artery, and the left gastro-epiploic from the splenic. Besides these, the great cul-de-sac receives the vasa brevia, which are branches of the splenic artery. After ramifying between the several coats and supplying them with blood, and especially after dividing into very small vessels on the submucous cellular tunic, the ultimate arterial branches enter the mucous membrane, and ramifying freely, pass to its surface between the tubuli, and end in a capillary network upon the hexagonal borders of the alveoli. The *veins*, corresponding with the arteries, return the residual blood into the splenic and superior mesenteric veins, and also directly into the vena portæ.

The *absorbents* are very numerous; they form a deep and a superficial set, and pass through lymphatic glands found along the two curvatures of the stomach.

The *nerves*, which are large, consist of the terminal branches of the two pneumogastric nerves, belonging to the cerebro-spinal system, and of offsets from the sympathetic system, derived from the solar plexus. The left pneumogastric nerve descends on the front, and the right upon the back of the stomach.

The Pylorus.—While there is no special apparatus at the cardiac orifice of the stomach for closing the passage from the œsophagus, the opening at the pyloric end, leading from the stomach into the duodenum, is provided with a sphincter muscle. On looking into the pyloric end of the stomach, the mucous membrane is seen projecting in the

form of a circular fold, called the *pylorus*, leaving a correspondingly narrow opening. Within this fold are circular muscular fibres, belonging to the general system of circular fibres of the alimentary canal, which are here accumulated in the form of a strong band, whilst the longitudinal muscular fibres and the peritoneal coat pass over the pyloric fold to the duodenum, and do not enter into its formation. Externally the pylorus may be easily felt, like a thickened ring, at the right end of the stomach. Internally its opening is usually circular, and less than half an inch across, so that it is the narrowest part of the whole alimentary canal. Occasionally the orifice is oval, and it is often placed a little to one side. Sometimes the circular rim is imperfect, and there are found instead two crescentic folds, placed one above and the other below the passage (Huschke); and, lastly, there is occasionally but one such crescentic fold.

THE SMALL INTESTINE.

The remaining part of the alimentary tube, extending from the stomach to the anus, constitutes the *intestines*, or the intestinal canal. It is divided into two portions, one named the small intestine, in which the bile and the pancreatic juice are added to the digestive mass, and the fluid chyle is formed and fitted for absorption by the lacteal vessels; and the other called the large intestine, through which the residual and excrementitious matter is conveyed out of the body.

The *small intestine* (intestinum tenue; fig. 448, [6], [7], [8],) reaches from the pylorus to the ileo-colic valve, at which it opens into the large intestine. It consists of a long tube, having a convoluted course, measuring on an average about twenty feet in the healthy adult, and becoming gradually, though slightly, narrower from its upper to its lower end. Its numerous convolutions occupy the middle regions of the abdomen, and are surrounded by the large intestine. They are connected with the back of the abdominal cavity, and are held in their position by a covering and fold of the peritoneum, named the mesentery, and by numerous blood-vessels and nerves.

The small intestine is arbitrarily divided into three portions, which have different names; the first eight or ten inches immediately succeeding to the stomach, and comprehending the widest and most fixed part of the tube, being called the *duodenum* ([6]), the upper two-fifths of the remainder being named the *jejunum* ([7]), and the lower three-fifths the *ileum* ([8]). There are no distinct lines of demarcation between these three parts, but there are certain peculiarities of connexion and certain differences of internal structure to be observed in comparing the upper and lower ends of the entire tube, which will be pointed out after it has been described as a whole.

Structure.—The walls of the small intestine are composed of four coats, resembling those of the stomach in their nature and relative position, and named accordingly the serous, muscular, cellular, and mucous coats.

The external or *serous* coat is a thin transparent tunic, smooth on its outer surface, and attached firmly at its inner side by means of cellular tissue to the succeeding or muscular coat. Derived from the

peritoneum, this serous coat almost entirely surrounds the intestinal tube, leaving only a narrow interval along one border of the intestine, where it is reflected from it and becomes continuous with the two layers of the peritoneal duplicature named the mesentery. The line at which this reflection takes place is named the *attached* or *mesenteric border* of the intestine. The opposite border and sides of the tube, which are covered by the peritoneum, are quite free and movable upon the adjacent parts.

The mesentery itself, which is some inches broad, is connected at its posterior margin with the back of the abdomen, so that it serves to support the intestine, and at the same time leaves it capable of a considerable degree of movement. The blood-vessels, lacteals, and nerves are also conveyed along the mesentery, and reach the intestine at its attached border, where for a small space the serous coat is wanting.

The upper part of the small intestine, named the duodenum, is but partially covered by the peritoneum, which there forms no mesentery.

The *muscular* coat consists of two layers of fibres; an outer longitudinal, and an inner or circular set. The *longitudinal* fibres are but very thinly scattered, and are most obvious along the free border of the intestine. The *circular* layer is much thicker and more distinct; its fibres are placed closely together, and run in a circular direction around the bowel, but it does not appear that they individually form perfect rings.

This muscular tunic becomes gradually thinner towards the lower part of the small intestine. It is pale in colour, and is composed of plain muscular fibres. The progressive contraction of these fibres, commencing in any part of the intestine, and advancing in a downward direction, produces the peculiar *vermicular*, or *peristaltic* movement, by which the digestive mass is forced onwards through the canal. In this movement the circular fibres are mainly concerned; but the longitudinal fibres also aid in it; and those found along the free border of the intestine will evidently straighten or unfold, as it were, its successive convolutions.

The *cellular* coat of the small intestine is a tolerably distinct and whitish layer, of a loose texture, which is connected more firmly with the mucous than with the muscular coat, between which two it is placed. By turning a portion of the intestine inside out, and then blowing forcibly into the cavity, the cellular tunic may be inflated, the air being driven into its areolar tissue, through the part at which the peritoneal investment is wanting. This cellular, or, as it is by some named, submucous coat, supports the mucous membrane, and forms a sort of layer in which the vessels divide and subdivide into smaller branches preparatory to entering the mucous tissue. It consists of filamentous cellular tissue, mixed with fine elastic fibres.

The internal or *mucous* coat is characterized by presenting all over its inner surface a fine flocculent, or shaggy appearance, like the pile upon velvet, owing to its being covered with multitudes of minute processes, named *villi;* hence it is also named the *villous* coat. It is

one of the most vascular membranes in the whole body, and it is naturally of a reddish colour in the upper part of the small intestine, but becomes paler, and at the same time thinner towards the lower end. It presents for further consideration, 1. the epithelium; 2. the large *folds* called *valvulæ conniventes;* 3. the *villi;* 4. the *glands;* and 5. the vessels.

1. *Epithelium.*—Every part of the surface is covered by a thin, transparent *epithelium*, of the columnar or cylindrical kind. The prismatic particles of this covering are represented in fig. 454.

2. *Valvulæ Conniventes.*—The folds and wrinkles found upon the inner surface of the œsophagus and stomach may be completely obliterated by full distension of those parts of the alimentary canal. In the lining membrane of the small intestine, however, there exist, beside such effaceable folds, other permanent ones, which cannot be obliterated, even when the tube is forcibly distended. These permanent folds are the *valvulæ conniventes*, or valves of Kerkring. They are crescentic projections of the mucous membrane, placed transversely to the course of the bowel, each of them reaching only about one-half or two-thirds of the distance around the interior of the tube, and following closely upon one another along the intestine.

The largest of these valves are about two inches long and one-third of an inch wide at the middle or broadest part; but the greater number are under these dimensions. Large and small valves are often found to alternate with each other. Some of them are bifurcated at one end, and others terminate abruptly, appearing as if suddenly cut off. Each valve consists of a fold of the mucous membrane, that is, of two layers placed back to back, united together by cellular tissue. They contain no muscular fibres, and are therefore not contractile. Being extensions of the mucous membrane, they serve to increase the absorbent surface to which the food is exposed, and at the same time they contribute to delay its passage along the intestine.

There are no valvulæ conniventes quite at the commencement of the duodenum; about an inch or somewhat more below the pylorus they begin to appear; beyond the point at which the bile and pancreatic juice are poured into the duodenum they are very large, regularly crescentic in form, and placed near to each other; they continue thus through the rest of the duodenum and along the upper half of the jejunum; below that point they begin to get smaller and further apart; and finally, towards the middle of the ileum, having gradually become more and more irregular and indistinct, sometimes even acquiring a longitudinal direction, they altogether disappear.

3. *Villi.*—The *villi*, peculiar to the small intestine, which give to its internal surface the velvety or villous appearance already spoken of, are small, elongated, and highly vascular processes, which are found situated closely together over every part of the mucous membrane, upon the valvulæ conniventes, as well as between them. (See fig. 455.) They are best displayed by putting a piece of intestine, well cleansed from its mucus, under water, and examining it with a simple lens. The prevalent form of the villi is that of minute, flattened, triangular processes; others are conical or cylindrical, or even clubbed at the

free extremity. Two or even three villi are occasionally seen connected together at their base.

Their *length* varies from $\frac{1}{4}$th to $\frac{1}{3}$d of a line, or even more; and the broad flattened kinds are about $\frac{1}{6}$th or $\frac{1}{8}$th of a line wide, and $\frac{1}{20}$th or $\frac{1}{24}$th of a line thick. They are largest and most numerous in the duodenum and jejunum, and become gradually shorter, smaller, and fewer in number in the ileum. In the upper part of the small intestine Krause has estimated their number at from 50 to 90 in the square line; and in the lower part at from 40 to 70 in the same space: he calculates their total number to be at least four millions.

The *structure* of these villi is complicated: each consists of a prolongation of the simple membrane, which forms the surface of the proper mucous layer, covered by epithelium and inclosing blood-vessels and lacteal vessels, with a greater or less number of small granular corpuscles and fat globules, of various sizes: nerves have not yet

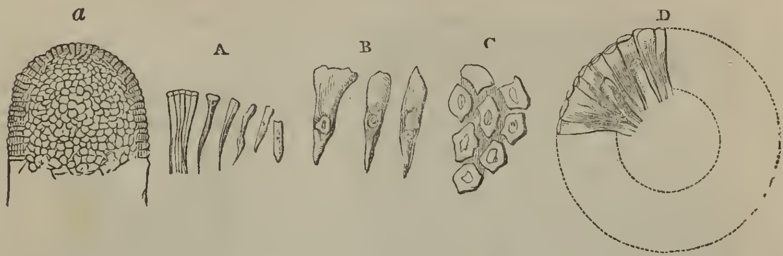
Fig. 453.

Magnified view of the blood-vessels of the intestinal villi, showing an artery and vein, and a superficial capillary network. After a preparation injected by Lieberkuehn.

been demonstrated in the villi, though they probably are not wanting. Each villus receives one or more small *arterial* twigs, which divide, and form upon its surface, beneath the epithelium and limiting membrane, a fine capillary network, from which the blood is returned for the most part by a single *vein*. The villi also contain *absorbent* vessels, which at the base of each villus pass into the general network of the lacteals of the mucous membrane. Their mode of origin within the villi is not yet determined with certainty. By most old observers, as Lieberkuehn, Hunter, Cruikshank, and Hewson, the lacteals were supposed to commence at the free surface of the villi by one or more *open* mouths; but all the modifications of this opinion are now given up, and the best authorities agree in believing that they form a *closed* system of vessels. This view, indeed, has been advocated by Mascagni, Albert Meckel, and Rudolphi, who considered that they commenced by a *network*. Henlé states that he has found only a single lacteal vessel, with a free, distended, but closed extremity in each cylindrical villus, and two such vessels not anastomosing together in the broader villi. Krause has figured the main lacteal of a villus as beginning by several branches, some having free and closed extremities, and others joining in a network; but it is questionable whether this

appearance may not be owing to reticular vessels imperfectly filled. The epithelium (fig. 454) forms a thin, transparent, but very distinct

Fig. 454.



Epithelium of small intestine, magnified. (Henlé.)—*a.* Ideal representation of the surface of a villus, showing the ends of the epithelium particles. A, B. Columns of epithelium from the intestine, magnified. C. Viewed by their broad free extremity. D. Seen in a transverse section of an intestinal villus. (From Henlé.)

layer upon the surface of the villi. (*a.*) It resembles the epithelial covering of the rest of the mucous membrane, and consists of elongated, prismatic, columnar particles (A B C), arranged compactly together, and perpendicularly to the surface (D).

4. *Glands.*—The glandular structures found in the mucous coat of the small intestine are the crypts or follicles of Lieberkuehn, the solitary glands, the patches of Peyer's glands, and Brunner's glands, the last being peculiar to the duodenum.

The *crypts* of Lieberkuehn, the smallest of these glandular structures, are found in every part of the small intestine, between the villi and surrounding the larger glands. They consist of minute tubes, closed at their attached extremity, and placed more or less perpendicularly to the surface, upon which they open by little orifices. (See figs. 455, 456.) They appear to be analogous to the tubuli of the stomach, but they are invariably simple in form, and are placed further apart from each other. Similar tubules are found in the large intestine also. The crypts of Lieberkuehn vary in length from the $\frac{1}{50}$th to the $\frac{1}{20}$th of a line, and their diameter is about $\frac{1}{50}$th of a line. The walls of the tubes are thin, and lined with a columnar epithelium: their contents are fluid and transparent, with granules interspersed. These crypts are sometimes filled with a whitish substance, which most probably consists chiefly of desquamated epithelium and mucus.

The *agminated glands*, or *glands of Peyer*, (who discovered and described them in 1677,) are found in groups or patches, having an oblong figure, and varying from half an inch to two or even four inches in length, and being about half an inch or rather more wide. These patches are placed lengthways in the intestine at that part of the tube most distant from the mesentery; and hence, to obtain a view of them, the bowel should be opened along its attached border.

The patches of Peyer's glands (see fig. 455 and its description) consist of groups of small, round, flattened vesicles or capsules, usually filled with a whitish semi-fluid matter, and situated beneath the mucous membrane, the surface of which is depressed into little shallow pits,

at or rather under the bottom of which the capsules are placed. The intermediate surface of the membrane is beset with villi and Lieber-

Fig. 455.

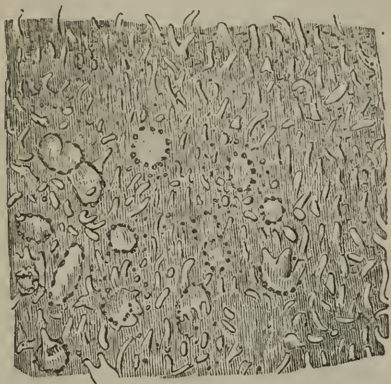


Fig. 456.

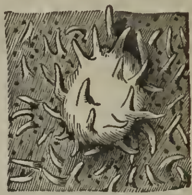


Fig. 455. Enlarged view of a part of a patch of Peyer's glands. (Boehm.) It shows the different forms of the individual vesicles, the zone of foramina belonging to Lieberkuehn's follicles around each, the mouths of other of those follicles and numerous villi situated between the vesicles, not upon them, and, lastly, the surrounding darker part of the mucous membrane beset merely with villi and follicles.

Fig. 456. Solitary gland of the small intestine, magnified. (Boehm.) The surface is beset with villi: the mouths of numerous crypts of Lieberkuehn are also seen.

kuehn's crypts: the villi are also sometimes found even over the capsules, and the crypts are collected in circles around the capsules, but do not communicate with them. In some subjects these small capsules are found almost empty, and then they are difficult of detection. They are usually entirely closed; but it has been supposed that they open from time to time to discharge their contents into the intestine, for Krause has observed that in the pig they are occasionally open, and a similar observation has since been made by Dr. Allen Thomson, not only in the pig, but in the human intestine also.

Opposite to the patches of Peyer's glands, the mucous and cellular coats of the intestine adhere more closely together than elsewhere, so that in those situations it is impossible to inflate the cellular coat. The corresponding parts of the intestine are also exceedingly vascular; and the lymphatic vessels form plexuses, which correspond in figure with the patches and may be very readily injected.

In all, there are from twenty to thirty of these oblong patches. They are larger and placed at shorter distances from each other, in the lower part of the ileum; but in the upper portion of that intestine and in the lower end of the jejunum, the patches occur less and less frequently, become smaller, and are of a nearly circular form.

Still smaller irregularly shaped clusters of these capsules are found scattered throughout the intestine, and may be regarded as transitions to the next form of glands, named *solitary*, which differ from the agminated glands only in the circumstance of being separate.

The *solitary glands* (glandulæ solitariæ) are soft, white, rounded, and slightly prominent bodies, about the size of a millet seed, which are found scattered over the mucous membrane in every part of the

small intestine. They are found on the mesenteric as well as on the free border, between and upon the valvulæ conniventes, and are rather more numerous in the lower portion of the bowel. These small glands have no orifice, but consist of closed vesicles or capsules (fig. 456), exactly resembling those forming the clusters of Peyer's glands, having rather thick but easily destructible walls, and usually containing in their interior an opaque, whitish fluid, which abounds in fine granules. The free surface of the capsules, which is slightly elevated when they are full, is beset with the intestinal villi; and, placed around them very irregularly, are seen the open mouths of the crypts of Lieberkuehn.

The nature of the solitary and agminated glands is, after all, very obscure, and their use not understood. From the observations of Krause and Thomson, it is to be presumed that their thick and granular contents are poured from time to time into the intestinal canal.

Brunner's glands are small rounded compound glands, first pointed out by Brunner, which exist in the duodenum, where they are most numerous at the upper end; according to Huschke, they are also found quite at the commencement of the jejunum. They are imbedded in the cellular tunic, and may be exposed by dissecting off the muscular coat from the outside of the intestine. They are true compound glands, consisting of minute lobules, and containing branched ducts, which open upon the inner surface of the intestine. Their secretion has not been examined, but it is probably of importance in the digestive process.

5. *Blood-vessels and absorbents.*—The branches of the mesenteric artery, having reached the attached border of the intestine, pass round its sides, dividing into numerous ramifications and frequently anastomosing at its free border. Most of the larger branches run immediately beneath the serous tunic: many pierce the muscular coat, supplying it with vessels as they pass, and having entered the submucous cellular layer, ramify in it, so as to form a close network, from which still smaller vessels pass on into the mucous coat, and terminate in the capillary network of the folds, villi, and glands of that membrane, which is the most vascular of all the intestinal tissues. The fine capillaries of the muscular coat are arranged in two layers of oblong meshes, which accompany and correspond in direction with the longitudinal and circular muscular fibres. The *veins* accompany the arteries.

The *absorbents* are also very numerous, and consist of a superficial and a deep set, which commence by a network on the mucous and serous surfaces of the bowel. The superficial network forms longitudinal meshes arranged like the fibres of the external muscular layer; while the deep set, in which the lacteals of the villi terminate, form a network with meshes arranged transversely like the circular muscular fibres. The two sets unite freely together, and at the attached border of the intestine end in numerous large vessels, which pass off between the layers of the mesentery, and enter the mesenteric glands.

THE DUODENUM.

The *duodenum* (fig. 473, *d*) extends from the pylorus (*p*) to the

place where the superior mesenteric vessels (the artery is marked *n*), coming forwards beneath the lower border of the pancreas, cross vertically over the intestinal tube to reach the root of the mesentery.

This is the shortest and widest part of the small intestine. It measures only 8 or 10 inches, or nearly about the breadth of *twelve* fingers; hence its name.

Its diameter varies between an inch and a half, and an inch and three quarters.* The course of the duodenum is also peculiar, for it describes a single large curve somewhat resembling a horseshoe, the convexity of which is turned towards the right, whilst the concavity is in the opposite direction, and embraces the head of the pancreas.

It is also placed more deeply, and held more fixedly in its position than the rest of the small intestine. It has no mesentery, and is covered only partially by the peritoneum. Its muscular coat is thicker; and its mucous membrane the seat of the compound glands of Brunner. Lastly, the common bile-duct and the pancreatic duct open into this part of the intestinal canal.

Three portions of the duodenum, differing from each other in their course and connexions, are separately described by anatomists; viz., the ascending, descending, and transverse portions.

The first, or *ascending* portion, which is about two inches long, commences at the pylorus, and passing upwards, backwards, and to the right side, reaches as far as beneath the neck of the gall-bladder, where the intestine bends suddenly downwards. This first portion of the duodenum is for the most part free, and entirely surrounded by the peritoneum. Above, and in front of it, are the liver and gall-bladder, and it is commonly found stained by the exudation of bile from the latter a few hours after death. Behind it, is the hepatic duct, with the blood-vessels passing up to the liver.

The second, or *descending* portion, commencing at the bend below the neck of the gall-bladder, passes vertically downwards in front of the right kidney as low as the second or third lumbar vertebra, where the bowel turns across to the left to form the transverse portion. This part of the duodenum is the least perfectly invested by the peritoneum, which covers only its anterior surface,—the posterior surface being connected to the right kidney and the vertebral column, by cellular tissue. In front is the transverse colon and meso-colon, the upper layer of which is continuous with the peritoneal covering of the duodenum. To the left is the head of the pancreas, which adapts itself to the shape of the intestine on that side. The common bile-duct descends behind the left border of this part of the duodenum, and together with the pancreatic duct, which accompanies it for a short distance, perforates the coats of the intestine obliquely at the lower part of its left or concave border. In the interior of this part of the intestine, the valvulæ conniventes begin to appear; and an eminence or papilla found about four inches below the pylorus, on the inner and back part of the intestine, marks the situation of the common orifice of the biliary and pancreatic ducts.

* These and other measurements relating to the intestinal canal are given on the authority of Huschke.

The third, or *transverse* portion, somewhat the longest and narrowest, crosses obliquely from right to left, in front of the second lumbar vertebra, ascending a little so as to end in the jejunum at the left side of that bone. It is placed immediately behind the root of the transverse meso-colon, the two layers of which passing, the one upwards, and the other down, afford it a covering in front. Behind, it is attached by cellular tissue to the vertebral column, the pillars of the diaphragm, the vena cava, and the aorta. Along its upper border it is connected by vessels and cellular tissue with the pancreas. The superior mesenteric vessels pass from beneath the pancreas over the intestine at the point where it terminates in the jejunum.

Vessels and nerves.—The vessels which supply the duodenum are derived from the superior pancreatico-duodenal and pyloric branches of the hepatic artery, and from the inferior pancreatico-duodenal branch of the superior mesenteric artery. Its veins open into the gastro-duodenal and superior mesenteric vein. Offsets from the solar plexus, directed along the arteries, supply it with nerves.

THE JEJUNUM AND ILEUM.

The *jejunum*, so called from its being generally found empty after death, follows the duodenum, and includes the upper two-fifths of the remainder of the small intestine; while the succeeding three-fifths constitute the *ileum*, so named from its numerous coils or convolutions. Both the jejunum and the ileum are attached and supported by the mesentery. The convolutions of the jejunum are situated in part of the umbilical and left iliac regions of the abdomen; while the ileum occupies part of the umbilical and right iliac regions, together with the hypogastric, and even descends into the pelvis, from which its lower end, supported by the mesentery, which is here very short, ascends obliquely to the right and somewhat backwards, over the corresponding psoas muscle, and ends in the right iliac fossa, by opening into the inner side of the commencement of the large intestine. There is no defined limit between the jejunum and the ileum, but the character of the intestine gradually changes from its upper to its lower end, so that a comparison of portions of the two intestines, remote from each other, presents certain well-marked differences. Thus, the jejunum is wider, and its coats are thicker; it is more vascular, and therefore it has a deeper colour; its valvulæ conniventes are long, wide, and numerous; and the patches of Peyer's glands are smaller, less frequent, and mostly confined to its lower part. The ileum, on the other hand, is narrower; its coats are thinner and paler; the valvulæ conniventes are small, and gradually cease towards its lower end; lastly, the groups of Peyer's glands are larger and more numerous. The diameter of the jejunum varies from one inch and a half to one inch; that of the ileum from one inch and a quarter to less than an inch. A given length of the jejunum accordingly weighs more than the same of the ileum.

Vessels and nerves.—The jejunum and ileum receive their numerous vessels from the superior mesenteric artery and vein. Their nerves descend along the arterial branches from the solar plexus.

THE LARGE INTESTINE.

The *large intestine* (intestinum crassum: fig. 448,[9 to 15]), which extends from the termination of the ileum to the anus, is distinguished from the small intestine by its direction, its size, and its sacculated form. It differs also in the thickness and structure of its muscular and mucous coats.

It commences in the right iliac fossa, and ascends through the lumbar region into the right hypochondrium ; then, turning suddenly to the left, it passes across the front of the abdomen, opposite to the confines of the epigastric and umbilical regions, into the left hypochondrium ; again altering its direction, it bends downwards and descends through the left lumbar to the left iliac region, where it makes a double turn upon itself; finally, it dips into the pelvis, and following the front of the sacrum and coccyx, terminates at the anus. In this course, the large intestine describes the greater part of a circle, which occupies the several regions already mentioned, reaches as high as the liver and stomach, and surrounds the convolutions of the small intestine.

The large intestine is divided by anatomists into the cæcum (including the vermiform appendix), the colon, and the rectum; and the colon is again subdivided, according to its direction, into four parts, called the ascending, transverse, and descending colon, and the sigmoid flexure.

The large intestine is held in its position, in some places by peritoneal folds resembling the mesentery ; and, in others, by a partial covering of peritoneum, and where this is deficient, by cellular tissue, which connects it to the back of the abdominal and pelvic cavities. On the whole it is more fixed, and therefore less liable to displacement, than the small intestine.

The length of the large intestine is usually about five or six feet; being about one-fifth of the whole length of the intestinal canal. Its diameter, which greatly exceeds that of the small intestine, varies at different points from two inches and a half to about one inch and a half. It diminishes gradually from its commencement at the cæcum, to its termination at the anus; excepting that there is a well-marked dilatation of the rectum just above its lower end.

In outward form, the greater part of the large intestine differs remarkably from the small intestine; for, instead of representing an even cylindrical tube, its surface is thrown into numerous sacculi, marked off from each other by intervening constrictions, and arranged in three longitudinal rows, separated by three flat bands of longitudinal muscular fibres. This sacculated structure is not found in the rectum.

Structure.—The walls of the large intestine consist of four coats, resembling those of the small intestine, namely, the serous, muscular, cellular, and mucous.

The *external* or *serous* coat, derived from the peritoneum, forms a complete investment only to certain portions of the intestine; in other parts the serous covering is incomplete; and at the lower end of the tube it is entirely wanting. Along the colon, and upper part of the

rectum, the peritoneal coat is developed into numerous little pouches, filled with adipose tissue. These fatty processes are named *appendices epiploicæ.*

The *muscular* coat, like that of every part of the intestinal canal, consists of external longitudinal and internal circular fibres. The *longitudinal* fibres, though found in a certain amount all around the intestine, are, in the cæcum and colon, principally collected into three remarkable flat longitudinal bands. These bands, sometimes called the ligaments of the colon, are about half an inch wide, and half a line thick; they commence upon the bottom of the cæcum, at the attachment of the vermiform appendix, and may be traced along the whole length of the colon as far as the commencement of the rectum, where they spread out, so as to surround that part of the intestinal tube with a continuous layer of longitudinal muscular fibres. One of these bands, named the *posterior*, is placed along the attached border of the intestine; another corresponds with its *anterior* border, and, in the transverse colon, is situated at the attachment of the great omentum; whilst the third band (*lateral*) is found along the free side of the intestine, that is, on the inner border of the ascending and descending colon, and on the under border of the transverse colon. It is along the course of this third band that the appendices epiploicæ are most of them attached. Measured from end to end, these three bands are shorter than the membranous part of the tube, so that in the intervals between the bands this is puckered or thrown into the sacculi already mentioned. Accordingly, if the longitudinal bands be stripped off, the sacculi are obliterated, and the intestine is lengthened. The transverse constrictions, seen outwardly between the sacculi, appear on the inside of the intestine as sharp ridges separating the cells, and are composed of all its coats.

The *circular* muscular fibres form but a thin layer over the general surface of the cæcum and colon, but are accumulated in larger numbers between the sacculi. In the rectum, especially towards its lower part, the circular fibres form a very thick and powerful muscular layer.

The *cellular* or submucous coat requires no special notice.

The *mucous* membrane is on the whole pale, but is much redder and darker in the rectum than elsewhere. It differs from the lining membrane of the small intestine in having no folds, like the valvulæ conniventes, and also in being quite smooth and destitute of villi. Viewed with a lens, its surface is seen to be marked all over by the orifices of numerous tubuli (fig. 458, C, D), resembling those of the stomach and the crypts of the small intestine. These follicles are arranged perpendicularly to the surface of the membrane; they are longer and more numerous, and are placed more closely together and at more regular intervals than those of the small intestine. Their orifices are circular, and they give the mucous membrane a cribriform aspect.

Besides these, there are scattered over the surface of the whole large intestine numerous rounded, whitish, glandular bodies, about $\frac{1}{3}$ or $\frac{1}{2}$ a line in diameter, and therefore much larger than the tubuli. These are follicular recesses or crypts (fig. 457, A, B), very simple in

structure. Their orifice is narrowed, but it leads into a dilated cavity, having thin walls, closely surrounded by the small perpendicular tubuli. They are most abundant in the cæcum and in its vermiform appendix.

Fig. 457.

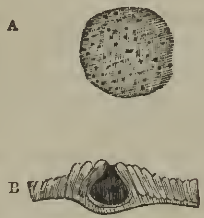


Fig. 458.

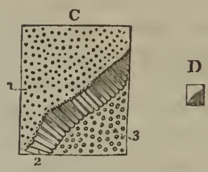


Fig. 457. One of the solitary follicles viewed from above at A, and seen in section at B; from the large intestine. (Boehm.)

Fig. 458. Tubuli and follicles of the large intestine, magnified. (Boehm.)—C. Tubuli, of which the mucous membrane principally consists. D. Natural size of same piece of membrane. 1. Their orifices seen on the surface. 2. Side view of the tubuli themselves. 3. Surface of the submucous or cellular coat, showing small pits corresponding with the closed ends of the tubuli.

The epithelium, which covers the general surface of the mucous membrane, and lines the tubuli and follicles, is of the columnar kind.

THE CÆCUM.

The cæcum (448,[9]) is that part of the large intestine which is situated below the entrance of the ileum; it is named *cæcum*, or the blind gut (caput cæcum coli), because it forms a cul-de-sac, or short rounded pouch extending downwards from the commencement of the colon, with which it is continuous above, without any line of demarcation. Its length is about $2\frac{1}{2}$ inches, and its diameter nearly the same: it is the widest part of the large intestine.

The cæcum is situated in the right iliac fossa, immediately behind the anterior wall of the abdomen. It is covered by the peritoneum in front, below, and at the sides; but behind it is usually destitute of peritoneal covering, and is attached by cellular tissue to the fascia covering the right iliacus muscle. In this case the cæcum is comparatively fixed; but in other cases the peritoneum surrounds it almost entirely, and forms a duplicature behind it, called the *meso-cæcum*.

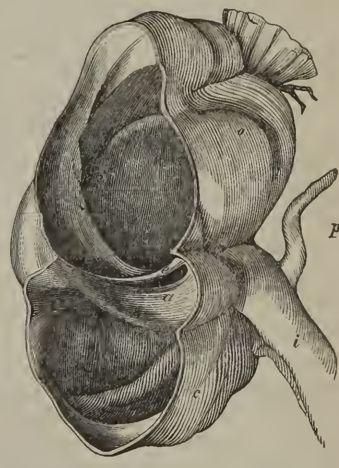
Proceeding from the inner and back part of the cæcum, at its lower end, is a narrow, round, and tapering portion of the intestine, named the *appendix cæci*, or, from its resemblance to a worm, *appendix vermiformis* ([10]). This process (fig. 459, *p*) is usually about the width of a large quill or rather more, and varies from three to six inches in length, differing much in its dimensions in different cases. Its general direction is upwards and inwards behind the cæcum, and after describing a few slight turns, it ends in a blunt point. It is retained in its position by a small fold of peritoneum, which forms a mesentery for it. This cæcal appendix is hollow down to its extremity; and its cavity communicates with that of the cæcum by a small orifice, sometimes guarded by a fold of mucous membrane. Its coats are the same

as those of the cæcum, and quite as thick. The longitudinal muscular fibres, which are continuous with those of the three bands described upon the cæcum and colon, form a uniform layer around the appendix. Its mucous membrane resembles that of the cæcum, but it is abundantly provided with the solitary follicular glands.

In the early embryo there is at first no cæcum. This part of the bowel gradually grows out from the rest, and in the first instance forms a tube of uniform calibre. In this state no appendix is seen; but subsequently the lower part of the tube, relatively speaking, ceases to grow, and becomes the vermiform appendix, whilst the upper portion continues to be developed with the rest of the intestine. A distinct appendix exists in the ourang-outang and in the wombat, but, as far as is known, in no other animal.

Ileo-cæcal, or *ileo-colic valve.*—The lower part of the small intestine (fig. 459, *i*), ascending from left to right, and from before backwards, enters the commencement of the large intestine, with a considerable degree of obliquity, about two inches and a half from the bottom of the cæcum (*c*), and opposite the junction of the latter with the colon (*o*), above. The opening leading from the ileum into the large intestine is guarded by a valve, composed of two segments, or folds (*e*, *a*). This is the *ileo-cæcal*, or *ileo-colic valve:* it is also called the valve of Bauhin and the valve of Tulpius, though Fallopius had described it before either of those anatomists.

Fig. 459.



Shows the junction of the small and large intestines, and, the cæcum and colon being laid open, displays the ileo-cæcal valve. *a.* The lower segment. *e.* The upper segment of the valve. *c.* The cæcum. *o.* The ascending colon. *i.* The end of the ileum. *p.* The appendix. From Santorini, slightly altered.

The entrance between the two segments of the valve, which is best displayed by laying open the commencement of the large intestine, along the right side, after it has been distended and dried, is a narrow elongated aperture, of a somewhat elliptical form, and having a nearly transverse or horizontal direction. The anterior end of this aperture, which is turned slightly to the left, is rounded, but the posterior end is narrow and pointed. It is bounded above and below by two prominent semilunar folds, which project inwards towards the cæcum and colon. The lower fold (*a*) is the larger of the two; the upper (*e*) is placed more horizontally. At each end of the aperture these folds coalesce, and are then prolonged as a single ridge for a short distance round the cavity of the intestine, forming the *fræna* or *retinacula* of the valve. The convex attached border of the upper fold corresponds with the line of connexion between the upper surface of the ileum and the colon, and that of the

lower fold with the junction of the under surface of the ileum and the cæcum. Their free concave margins are turned towards the large intestine, having a slight inclination upwards, and are brought into apposition when the cæcum is distended, so as completely to close the aperture and mechanically prevent any influx into the ileum.

Each segment of the valve consists of two layers of mucous membrane, continuous with each other along the free margin, and including between them, besides the submucous cellular tissue, a number of muscular fibres, continued from the circular fibres of the ileum and from those of the large intestine also. The longitudinal muscular fibres and the peritoneal coat take no part in the formation of the valve, but are extended uninterruptedly from one intestine to the other. If, indeed, the serous tunic, and the longitudinal muscular fibres be divided, the ileum may be drawn out, with the aid of a little cautious dissection, from the side of the large intestine, and the folds of the valve will be completely effaced,—the small intestine seeming then to open into the large, by a funnel-shaped orifice like that leading from the œsophagus into the stomach.

The mucous membrane covering the surface of each valvular segment which is turned towards the ileum, is derived from the lining membrane of that intestine, and is provided with its characteristic villi; while the other surface, turned towards the large intestine, is smooth and destitute of villi, and is more regularly marked with the orifices of the small tubuli. These differences are apparent quite up to the free margin of the valve, where the two kinds of mucous membrane become continuous.

THE COLON.

The *right* or *ascending* colon (fig. 448,[11]) situated in the right lumbar and hypochondriac regions, commencing at the cæcum opposite to the ileo-colic valve, ascends vertically to the under surface of the liver, near the gall-bladder, where it advances forwards and then turns abruptly to the left, forming what is named the *hepatic* flexure of the colon. The ascending colon is smaller than the cæcum, but larger than the transverse colon. It is overlaid in front by some convolutions of the ileum, and is bound down firmly by the peritoneum, which passes over its anterior surface and its sides, and generally leaves its posterior surface to be connected by cellular tissue with the fascia covering the quadratus lumborum muscle, and with the front of the right kidney. In some cases, however, the peritoneum passes nearly round it, and forms a distinct though very short right mesocolon.

The *transverse colon* ([12]) passes across from the right hypochondrium, through the upper part of the umbilical region, into the left hypochondrium. Sometimes it is found as low as the umbilicus or even lower. At each extremity it is situated deeply towards the back part of the abdominal cavity, but in the middle advances forwards, and lies close to the anterior wall of the abdomen. Hence it describes an arch, the concavity of which is turned towards the vertebral column; and it has accordingly been named the *arch* of the colon.

Above, the transverse colon is in contact with the under surface of the liver, the gall-bladder, the great curvature of the stomach, and the lower end of the spleen. Below it, are the convolutions of the small intestine, the third portion of the duodenum being behind it. By its posterior border it is attached to the meso-colon, a very large and wide duplicature of the peritoneum, which serves to connect this part of the large intestine to the back of the abdominal cavity, at the same time allowing it more freedom of movement than the other parts. The two layers of the meso-colon, having separated to enclose the transverse colon and form its peritoneal coat, meet again along its anterior border and become continuous with the great omentum, which therefore lies upon the intestine, and is connected with it. The lower border of the stomach also frequently rests upon the transverse colon.

The *left* or *descending* colon ([13]) is continuous with the left extremity of the transverse colon by a sudden bend, named the *splenic flexure.* It then descends almost perpendicularly through the left hypochondriac and lumbar regions to the left iliac fossa, where it ends in the sigmoid flexure. The peritoneum affords a covering to it only in front and at the sides, whilst behind it is connected by cellular tissue to the left crus of the diaphragm, the quadratus lumborum and the left kidney. It is usually concealed behind some convolutions of the jejunum.

The *sigmoid flexure* of the colon ([14]), situated in the left iliac fossa, consists of a double bending of the intestine upon itself in the form of the letter S, immediately before it becomes continuous with the rectum, at the margin of the pelvis opposite to the left sacro-iliac symphysis. It is covered all round by the peritoneum, which, however, is reflected from it behind to form a distinct meso-colon. By this the intestine is attached to the iliac fossa, but it is very movable. It is placed immediately behind the abdominal parietes, or is concealed only by a few turns of the small intestine. The sigmoid flexure is the narrowest part of the colon.

Vessels and Nerves.—The cæcum, and the ascending and transverse colon, receive their vessels from the right side of the superior mesenteric artery; and the descending colon and sigmoid flexure from the inferior mesenteric. The veins end in those which accompany the arteries just named. The nerves are offsets from the superior and inferior mesenteric plexuses. Lastly, the absorbents enter the lymphatic glands placed along the blood-vessels.

THE RECTUM.

The lowest portion of the large intestine, named the *rectum* (fig. 448,[15] and fig. 478, *b b h*), extends from the sigmoid flexure of the colon to the anus, and is situated entirely within the true pelvis, at its back part.

Commencing opposite to the left sacro-iliac junction (fig. 478, *b*), it is directed at first obliquely downwards, and from left to right, to gain the middle line of the sacrum. It then changes its direction, and curves forward in front of the lower part of the sacrum and the coccyx, and behind the bladder, vesiculæ seminales, and prostate in the

male (b'), and at the back of the cervix uteri and vagina in the female. Opposite to the prostate (p), it forms another turn, and inclines downwards and backwards (h) to reach the anus. The *intestinum rectum*, therefore, is not actually straight. Seen from the front, the upper part of the rectum presents a lateral inclination from the left to the median line of the pelvis; and when viewed from the side (as in fig. 476), it offers two curves, one corresponding with the hollow front of the sacrum and coccyx, and the other at the lower end of the bowel, forming a shorter turn in the opposite direction.

Unlike the rest of the large intestine, the rectum is not sacculated, but is smooth and cylindrical; and it has no separate longitudinal bands upon it. It is about six or eight inches in length; and is rather narrower than the sigmoid flexure at its upper end, but becomes dilated into a large ampulla or reservoir, immediately above the anus.

The upper part of the rectum is in contact in front with the back of the bladder, (or uterus in the female,) unless some convolutions of the small intestine happen to descend into the interval between them. This part is surrounded by peritoneum (r), which attaches it behind to the sacrum by a duplicature named the *meso-rectum.* Lower down, the peritoneum covers the intestine in front and at the sides, and then its anterior surface only; still lower, it quits the intestine altogether, and is reflected forwards to ascend upon the back of the bladder (a) in the male, and of the upper part of the vagina and the uterus in the female. In passing from the rectum to the bladder, the peritoneum forms a cul-de-sac (r'), which extends between the intestine and the bladder to within a short distance of the prostate, and is bounded on the sides by two lunated folds of the serous membrane.

Below the point where the peritoneum ceases to cover it, the rectum (at b') is connected to surrounding parts by cellular tissue, which is mostly loaded with fat. In this way it is attached behind to the front of the sacrum and the coccyx, and at the sides to the coccygei and levatores ani muscles. In front, it is in immediate connexion with a triangular portion of the base of the bladder; on each side of this, with the vesiculæ seminales (v); and further forwards, with the under surface of the prostate (p). Beyond the prostate, where the rectum turns downwards to reach the anus, it becomes invested by the fibres of the internal sphincter, and embraced by the levatores ani muscles, which form a support for it. Lastly, at its termination it is surrounded by the external or proper sphincter ani muscles (h). In the female, this lower portion of the rectum is firmly connected with the back of the vagina.

Structure.—The rectum differs in some respects from the rest of the large intestine, viz., in regard to its muscular and mucous coats.

The muscular coat is much thicker: the external or longitudinal fibres form a uniform layer around it and cease near the lower end of the intestine; the internal or circular fibres, on the contrary, become more numerous in that situation, where they form what is named the internal sphincter muscle.* The longitudinal fibres are paler than the

* The longitudinal muscular fibres of the rectum, after reaching the lower margin of the internal sphincter, turn in between it and the external sphincter, and then ascend for

circular fibres, but both layers become darker and redder towards the termination of the bowel. The bands composing the internal sphincter muscle are found to contain striped muscular fibres.

The mucous membrane of the rectum is thicker, redder, and more vascular than that of the colon; and it moves freely upon the muscular coats—in that respect resembling the lining membrane of the œsophagus. It presents numerous folds of different sizes, and running in various directions, nearly all of which are effaced by the distension of the bowel. Near the anus these folds are principally longitudinal, and seem to depend on the contraction of the sphincter muscles outside the loosely connected mucous membrane. The larger of these folds were named by Morgagni the *columns* of the rectum (*columnæ recti*). Higher up in the intestine, the chief folds are transverse or oblique. Three prominent folds, larger than the rest, being half an inch or more in width, and having an oblique direction in the interior of the rectum, have been pointed out specially by Mr. Houston.* One of these projects backwards from the upper and fore part of the rectum, opposite the prostate gland; another is placed higher up, at the side of the bowel; and the third still higher. From the position and projection of these folds, they may more or less impede the introduction of instruments.

Vessels and Nerves.—The *arteries* of the rectum spring from three sources, viz., the superior hæmorrhoidal branches from the inferior mesenteric; the middle hæmorrhoidal branches from the internal iliac directly or indirectly; and, lastly, the external or inferior hæmorrhoidal branch from the pudic artery. The *veins* are very numerous, and form a complex interlacement, the hæmorrhoidal plexus, around the lower end of the bowel above the anus. They end partly in the internal iliac vein by branches which accompany the middle hæmorrhoidal artery, and partly in the inferior mesenteric vein. Hence, the blood from the rectum is returned in part into the vena cava, and in part into the portal system. The *lymphatics* enter some glands placed in the hollow of the sacrum, or those of the lumbar series. The *nerves* are also very numerous, and are derived from both the cerebro-spinal and the sympathetic systems. The former consist of branches derived from the sacral plexus; and the latter, of offsets from the inferior mesenteric and hypogastric plexuses.

THE ANUS AND ITS MUSCLES.

The *anus*, or lower opening of the alimentary canal, is a dilatable orifice, surrounded internally by the mucous membrane, and externally by the skin, which two structures here become continuous with and pass into each other. The skin around the borders of the anus, which is thrown into wrinkles or folds during the closed state of the orifice, is covered with numerous sensitive papillæ, and is provided with hairs and sebaceous follicles.

an inch or two, to be inserted into the fibro-vascular layer of the mucous membrane. Many of the terminating fibres are collected into fasciculi, which form the base of the columns of the rectum. Horner, Spec. Anat. and Hist. vol. ii. p. 49, Phil. 1846.—J. L.]

* Dublin Hospital Reports, vol. v.

The lower end of the rectum and the margin of the anus are, moreover, embraced by certain muscles, which serve to support the bowel, and to close its anal orifice. These muscles, proceeding from within outwards, are, the internal sphincter, the levatores ani (with which we may associate the coccygei), and, lastly the external sphincter ani.

The *internal sphincter* muscle (sphincter ani internus) is a muscular ring or rather belt, surrounding the lower part of the rectum, an inch above the anus, and extending over about half an inch of the intestine. It is two lines thick, and is paler than the external sphincter. Its fibres are continuous above with the circular muscular fibres of the rectum, and, indeed, it consists merely of those fibres more numerously developed than elsewhere, and prolonged down further than the external longitudinal fibres. Opposite to the internal sphincter, the mucous membrane of the rectum is elevated into a ring.

Fig. 460.

Muscles of the perinæal region. (Santorini.)—1. Ramus of ischium.—2. Coccyx. 3. Ischial spine and tuberosity. 4. Side of sacrum. *b, b.* Bulbo-cavernosus, or accelerator urinæ. *c, c.* Ischio-cavernosus, or erector penis. *d, d.* Transversi perinæi. *e.* External sphincter ani. *f.* Coccygeus. *l, l.* Levatores ani. *n.* Layer of fascia covering levator ani. *s.* Spongy part of the urethra. The probe is placed beneath the central fibrous structure of the perinæum.

The *external sphincter* (figs. 460, *e*, 478, *h;* sphincter ani externus) is a flat oval muscle, placed immediately beneath the skin surrounding the margin of the anus. It is elliptical in form, being about an inch wide opposite to the anus, and becoming narrow at its posterior and anterior extremities, which are between three and four inches apart, and are fixed, one to the coccyx, and the other to the middle point of the perinæum.

Posteriorly, it is attached to the tip and back of the coccyx, (fig. 460,[2]) by means of a narrow bundle of tendinous fibres; whilst, anteriorly, in front of the anus, about midway between that orifice and the bulb of the urethra (in the male), it becomes blended, (near the probe in fig. 460,) through the medium of a common fibrous structure, with the transverse muscles of the perinæum, (*d*,) and with the muscles embracing the urethral bulb, (*b, b.*) In the female, the anterior extremity of the external sphincter unites with the constrictor vulvæ and the transversi perinæi muscles. The intermediate and wider portion of the sphincter is disposed like other orbicular muscles, and is composed of fleshy bundles, which embrace the intestine and intersect each other, or unite in a commissure before and behind it.

The lower or external surface of this muscle is covered only by the skin; the upper or internal surface is in contact with the paler fibres constituting the internal sphincter, and also with some cellular tissue

which separates it, though imperfectly, from the lowest fibres of the levatores ani muscles.

The action of the external and internal sphincters is sufficiently obvious.

The *levatores ani* muscles, (fig. 460, *l*, *l*,) one right and the other left, are two broad and thin muscular layers, which take origin from the inner surface of the sides of the true pelvis, and, passing obliquely downwards and inwards, meet across the outlet of that cavity, so as together to form a thin, funnel-shaped muscle, which embraces the parts descending through it, and constitutes, as it were, a movable floor to the pelvic cavity.

The *origin* of each levator muscle is most extensive; and, in order to explain it clearly, it is necessary to advert for an instant to the arrangement of the fasciæ of the pelvis, with which it is intimately connected. The pelvic fascia, in descending from the brim of the pelvis, covers the upper part of the internal obturator muscle, and may be traced as a single fibrous layer, as far as to a white line or band which stretches from near the symphysis pubis to the spine of the ischium. Along this line, the fascia may be said to split into two layers: one, named the obturator fascia, which continues downwards over the remainder of the internal obturator muscle; and the other, called the recto-vesical fascia, which passes inwards and downwards towards the side of the rectum, bladder, and prostate in the male, and of the rectum and vagina in the female.

Now the levator ani is situated between the obturator and recto-vesical fasciæ, in close contact, however, with the under surface of the last-named fascia, immediately beneath which it forms a broad and thin muscular stratum. The greater part of the muscle arises above, from along the angle of divergence of the obturator and recto-vesical fasciæ, that is, from the under surface of the white band above mentioned as stretching from near the symphysis pubis to the spine of the ischium. Besides this long line of origin from the fasciæ, the levator ani arises behind from the spine of the ischium ([3]), and, in front, from the posterior surface of the body and ramus of the pubes, near to the symphysis and close above the pubic arch.

From this extensive origin the fibres of the levator proceed downwards and inwards towards the middle line of the floor of the pelvis. Its hindmost fasciculi are inserted upon the side of the lower end of the coccyx; the bundles next in order, anteriorly, interlace or unite in a median raphé with the corresponding muscle, in the interval between the coccyx and the margin of the anus; the middle and larger portion of the muscle is prolonged upon the lower part of the rectum, where it is connected with the fibres of the internal, but more particularly of the external sphincter; and, lastly, the anterior muscular bundles pass between the rectum and the genito-urinary passages, and, descending (in the male) upon the side of the prostate, unite beneath the neck of the bladder, the prostate, and the neighbouring part of the urethra, with corresponding fibres from the muscle of the opposite side, and blend also with those of the external sphincter and deep transverse perinæal muscles.

The anterior portion of the levator ani, which arises from the ramus of the pubes, close to the symphysis and above the pubic arch, and also from the adjacent fasciæ, is sometimes separated at its origin by cellular tissue from the rest of the muscle. From this circumstance, and from its connexion with the prostate gland, it was described by Santorini, and since by Albinus and Sœmmerring, as a distinct muscle, under the name of the *levator prostatæ.* In the female, the anterior fibres of the levator ani descend upon the sides of the vagina, and are intimately connected with it.

The upper or pelvic surface of the levator ani is in contact with the recto-vesical fascia, and with part of the pelvic viscera. Its under or perinæal surface appears at the side of the external sphincter, in the ischio-rectal fossa, where it is covered by a thin layer of membrane derived from the deep perinæal fascia, and also by a large quantity of fat. The posterior border of the muscle is continuous with the coccygeus. Its anterior border does not reach the middle line in front, but leaves between it and the corresponding border of the opposite muscle an interval beneath the pubic arch, through which the genito-urinary passages have their exit from the pelvis.

The levatores ani support and elevate the lower end of the rectum, and also the bladder and prostate. They flex and at the same time fix the coccyx.

The *coccygeus* muscle is placed deeply on each side, at the back part of the outlet of the pelvis, and assists in closing that cavity, behind and below, by stretching across from the spine of the ischium to the sides of the sacrum and coccyx. This muscle is connected to, or even continuous with, the posterior part of the levator ani. It is composed of fleshy and tendinous fibres, forming a thin, flat, and triangular plane, which arises by its apex from the spine of the ischium and the lesser sciatic ligament, and is attached along its base to the border of the coccyx and the lower part of the sacrum. Its internal or pelvic surface assists in supporting the rectum; its external or under surface rests on the front of the sacrosciatic ligaments, and on the glutæus maximus muscle.

The coccygei muscles merely aid in flexing and fixing the coccyx.

DEVELOPMENT OF THE ALIMENTARY CANAL.

In the ovum of the bird, the mucous layer of the germinal membrane, which lies next to the yolk, soon comes to be distinguished into a central and a peripheral part. From the central part the alimentary canal is afterwards formed, whilst the circumference extends so as to enclose the yolk and form the yolk sac or vitelline sac, which after a time is drawn through the umbilicus into the abdomen of the chick.

In mammalia and man, the origin of the alimentary canal is precisely similar. It commences in the mucous layer of the blastoderm in form of a groove, which is soon changed into a tube at each end, but is left open in the middle upon the ventral aspect, and communicates by means of a tube, named the omphalo-enteric canal or vitelline duct, with the vitelline sac. This duct is soon obliterated, and the vitelline sac becomes the umbilical vesicle, which is henceforth connected with the embryo only by a slender elongated pedicle containing the omphalo-mesenteric vessels, and is finally atrophied.

The *alimentary canal* itself is at first a straight tube closed at each end, and

placed along the front of the vertebral column, to which it is closely attached above and below (supposing the embryo to be placed in an erect position), whilst in the middle of its course it is connected by a median membranous fold, or rudimental *mesentery*. Soon, however, it advances from the spine, and forms a simple bend in the middle of the body, with a straight portion at its upper and lower end. The middle or apex of the bend advances to the umbilicus, where it is connected with the umbilical vesicle by the pedicle, and also by the omphalo-mesenteric vessels, which pass out there to the vesicle.

By the early appearance of a slight dilatation, which forms the future stomach, the primitive simple tube is divided into an upper and a lower portion.

a. From the upper portion, besides the œsophagus, which is formed by a gradual elongation of the part, there are ultimately developed the mouth, tongue, and salivary glands, the pharynx, larynx, trachea, and lungs. At first the upper end is closed; at length a wide aperture appears, which is not the mouth, properly so called, but an opening upon which the mouth and lips are subsequently developed as superadded parts, commencing after the eighth or ninth week.

b. The dilated portion of the tube which forms the stomach turns over on its right side, so that the border, which is connected to the vertebral column by the membranous fold (or true mesogastrium) comes to be turned to the left,—the position of the tube being still vertical, like the stomach of some animals. By degrees it becomes more dilated, chiefly on what is now the left border but subsequently the great curvature, and assumes first an oblique and finally a transverse position, carrying with it the mesogastrium, from which the great omentum is afterwards produced. The pylorus is seen at the third month, but is very slightly marked. Immediately below the stomach, the duodenum is formed; and upon this part of the canal commence the rudiments of the liver, pancreas, and spleen, the two former having protrusions of the mucous membrane growing into their blastemic mass.

c. In the mean time the part below the stomach becomes the intestinal canal; that portion of it which is suspended by a mesentery forming (besides the duodenum) the jejunum, the ileum, the cœcum, and the colon, whilst the lower and attached part constitutes the rectum. The place of distinction between the small and the large intestine, which is soon indicated by the protrusion of the cœcum, is at a point just below the apex or middle of the simple bend already mentioned. As the *small* intestine grows, the part below the duodenum forms a coil, which at first lies in the commencing umbilical cord, but retires again into the abdomen about the tenth week; afterwards it continues to elongate, and its convolutions become more and more numerous. The diverticula sometimes found projecting from the small intestine are supposed to be developed from a persistent portion of the vitelline duct, which continues to grow with the rest of the bowel. The *large* intestine is at first less in calibre than the small. The development of the cœcum and its appendix has already been described (p. 465). It appears as a protrusion a little below the apex of the bend in the primitive intestinal tube, and, as well as the commencing colon, is at first lodged in the umbilicus with the coil of small intestine. The appendix is at first of equal width. The ileo-cœcal valve appears at the commencement of the third month. When the coils of intestine and cœcum have retired from the umbilicus into the abdomen, the colon is at first to the left of the convolutions of the small intestine, but then, together with the meso-colon, crosses over its upper part at the junction of the duodenum and jejunum. The cœcum and transverse colon are then found just below the liver; finally, the cœcum descends to the right iliac fossa. At the fourth or fifth month the parts are in the same position as in the adult.

The lower straight and attached portion of the tube eventually forms the rectum. The anal orifice does not exist at first, but appears a week or so later than the oral opening.

Coats of the intestine.—At a very early period the walls of the intestinal tube appear to consist of two layers, both of which are originally composed of nucleated cells. The outer one is more transparent than the other, and is supposed by Bischoff to be metamorphosed into the muscular and cellular coats, whilst the inner layer forms the mucous membrane. The serous coat is said to be developed afterwards upon the surface of the intestine, and, at the same time, upon that of

all the other abdominal organs, and on the walls of the abdomen. The mucous membrane is at first very thick, and is soon provided with a conspicuous layer of epithelium, which after a time accumulates in considerable quantities in the intestinal canal. At first, villous processes or folds of various lengths are formed throughout the whole cañal. After a time they disappear in the stomach and large intestine, but remain persistent in the intermediate portions of the tube. According to Meckel, they are formed from larger folds, which become serrated at the edge and divided into villi.

In the mean time, the mucous coat is completed by the development of the gastric tubules, the follicles of Lieberkuehn, and the solitary and agminated glands.

THE LIVER.

The liver (*hepar*, *jecur*, fig. 246, [1]) is the large gland which secretes the bile. It is very constant in the animal series, being found in all vertebrate, and, in a more or less developed condition, in most invertebrate tribes.

In the human subject, it is situated in the upper part of the abdominal cavity, occupying the right hypochondriac region, and extending across the epigastric region into a part of the left hypochondrium. It is placed immediately beneath the diaphragm, above the stomach, duodenum, and colon, behind the cartilages of the ribs, and in front of the vena cava, aorta, and crura of the diaphragm, which latter parts are interposed between the gland and the vertebral column.

The liver is a solid organ, of a dull reddish brown colour, with frequently a dark purplish tinge along the margin. It has an upper smooth and convex surface, and an under surface (fig. 461) which is uneven and concave: the circumference, or border at which these two surfaces meet, is thick and rounded behind and to the right, that is, at the posterior border and right extremity of the liver; but it becomes gradually thinner towards the left and in front, where it forms the left extremity and the sharp anterior margin.

The liver is the largest gland in the body, and by far the most bulky of the abdominal viscera. It measures about ten or twelve inches transversely from right to left, between six and seven inches from its posterior to its anterior border, and about three inches from above downwards at its thickest part, which is towards the right and posterior portion of the gland. The average bulk of the liver, according to Krause, is eighty-eight cubic inches. Its ordinary weight in the adult is stated to be between three and four pounds, or more nearly from fifty to sixty ounces avoirdupois.

According to the facts recorded by Dr. John Reid,* it weighed, in 43 cases out of 82, between 48 and 58 ounces in the adult male; and in 17 cases out of 36, its weight in the adult female ranged between 40 and 50 ounces. It is generally estimated to be equal to about 1-36th of the weight of the whole body; but in the fœtus, and in early life its proportionate weight is greater.

The specific gravity of the liver, according to Krause and others, is between 1·05 and 1·06: in fatty degeneration this is reduced to 1·03, or even less.

* Lond. and Edin. Monthly Journal of Med. Science, April, 1843.

The form, position, and connexions of the surfaces and borders of the Liver.—The *upper convex surface,* free, smooth, and covered by peritoneum, is accurately adapted to the vault of the diaphragm above, and is covered, to a small extent in front, by the abdominal parietes. The line of attachment of a fold of peritoneum, named the broad ligament of the liver, marks off this surface unequally into a right and a left portion. The right portion is much larger and more convex than the left, and reaches higher beneath the ribs, corresponding thus with the elevated position of the diaphragm on that side. By means of the diaphragm, the liver is separated from the concave base of the right lung, the thin margin of which descends so as to intervene between the surface of the body and the solid mass of the liver—a fact well known to the auscultator.

The convex surface of the liver is protected, on the right, by the six or seven lower ribs, and in front by the cartilages of the same and by the ensiform cartilage—the diaphragm, of course, being interposed. Being suspended by ligaments to the diaphragm above, and supported below, in common with the rest of the viscera, by the abdominal muscles, the situation of the liver is modified by the position of the body, and also by the movements of respiration: thus, in the upright or sitting posture, the liver reaches below the margin of the thorax; but in the recumbent position, the gland ascends an inch or an inch and a half higher up, and is entirely covered by the ribs, except a small portion opposite the substernal notch. Again, during a deep inspiration, the liver descends below the ribs, and in expiration retires behind them. In females the liver is often permanently forced downwards below the costal cartilages, owing to the use of tight stays: sometimes it reaches nearly as low as the crest of the ilium; and, in many cases, its convex surface is indented from the pressure of the ribs upon it.

The *under* or *concave* surface of the liver, (fig. 461,) which is directed downwards and backwards, is uneven. Besides several depressions found at its points of contact with other organs, as the stomach, colon, and kidneys, it presents certain divisions or lobes, and several fissures, to be presently described. The greater part of this surface is free and covered by the peritoneum; but this is not the case where the large vessels enter the gland, nor where it is attached by cellular tissue to adjacent parts. It is separated into two unequal parts, one right ([1]) and the other left ([2]), by a longitudinal or antero-posterior fissure ([6]). The part to the left of this fissure is supported on the pyloric extremity and anterior surface of the stomach, on which it moves freely. (See fig. 473, in which the liver is represented as turned upwards, with the stomach.) When the stomach is quite empty, the left part of this surface of the liver may overlap the cardiac end of that viscus. To the right of the longitudinal fissure the liver rests and moves freely upon the first part of the duodenum, and upon the hepatic flexure of the colon, at the juncture of the ascending and transverse portions of that intestine. Further back it is in contact with the fore part of the right kidney and suprarenal capsule, for which it presents one or two corresponding depressions. The gall-

bladder is also attached to this right portion of the under surface of the liver by peritoneum, loose cellular tissue, and vessels.

The *anterior border* of the liver, a thin, free, and sharp margin, is the most movable part of the gland. Opposite the longitudinal fissure and the line of attachment of the broad ligament, this anterior border presents a notch ([16]), which separates the right and left lobes of the liver, and lodges the round ligament. To the right of this notch there is often another slight one opposite the fundus of the gall-bladder ([10]).

The *posterior border* of the liver, which is directed backwards and upwards, is thick and rounded on the right side, but becomes gradually thinner towards the left. It is the most fixed part of the organ, and is firmly attached by cellular tissue to the diaphragm, the peritoneum being here reflected away from the liver on to the diaphragm, so as to form the *coronary* ligament. This border of the liver is curved opposite to the projection of the vertebral column, and has a deep groove for the reception of the ascending vena cava.

Of the two *extremities* of the liver, the *right* is placed lower down, and is thick and obtuse; whilst the *left* is the thinnest part of the gland, and ascends to a higher level, reaching across to the cardiac end of the stomach. Both extremities are attached to the diaphragm by peritoneal folds, named the lateral ligaments.

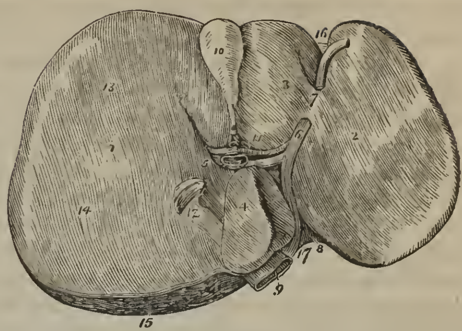
Besides being attached to large blood-vessels, and supported by the parts beneath and by the abdominal muscles, the liver is suspended by its ligaments, which are five in number.

The Ligaments.—These are five in number, and, with one exception (the ligamentum teres), are formed merely by folds of the peritoneum. 1. The *broad, falciform*, or *suspensory* ligament is a wide thin membrane, composed of two layers of peritoneum, closely united together. By one of its margins it is connected with the under surface of the diaphragm, and with the posterior surface of the sheath of the right rectus muscle of the abdomen, as low as the umbilicus; and by another it is attached along the convex surface of the liver, from its posterior border to the notch in its anterior border. The remaining margin of the ligament is free, and contains between its layers the round ligament. 2. The *round* ligament (ligamentum teres) is a dense fibrous cord, which ascends from the umbilicus, within the lower edge of the broad ligament, towards the notch in the anterior border of the liver, and there enters the longitudinal fissure on the under surface. It is the remains of the umbilical vein of the fœtus. 3. The *coronary* ligament is formed by the reflection of the peritoneum from the diaphragm to the posterior border of the liver. In this situation there is a broad triangular portion of the gland, which is attached by firm cellular tissue to the diaphragm, and the surrounding reflection of the peritoneal membrane constitutes the coronary ligament. 4 and 5. Both on the right and the left end of the liver the peritoneum also forms a triangular reflection, extending to the adjacent part of the diaphragm: these are the *right* and *left lateral* or *triangular* ligaments, of which the left is longer and more distinct than the other.

The Lobes.—The lobes of the liver, like the ligaments, are five in

number; and, indeed, anatomists have endeavoured to trace the number five in respect also of the fissures and vessels of the gland. The *lobes* are named the right and the left, the lobe of Spigelius, the caudate or tailed lobe, and the square lobe. 1, 2. The *right* and *left* lobes (fig. 461,[1],[2]) are separated from each other on the under surface by the longitudinal fissure ([6]), and in front by the interlobular notch: on the convex surface of the liver there is no other indication of a separation between them than the line of attachment of the broad ligament. The right lobe is of a long square form; it is much larger and thicker than the left, which is nearly triangular in outline, and constitutes only about one-fifth or one-sixth of the entire gland. 3, 4, 5. The other three lobes are small, and might be said to form a part of the right lobe, on the under surface of which they are situated. The *Spigelian* lobe ([4], lobulus Spigelii) projects in the form of a pyramidal mass from the middle of the back part of the liver, and is bounded by three large fissures, to be immediately described, which lodge the vena portæ, the vena cava, and the remains of the ductus venosus. The *caudate* or *tailed* lobe ([5]) is a sort of ridge which extends from the base of the Spigelian lobe to the under surface of the right lobe. This, in the natural position of the parts, passes forwards above the foramen of Winslow, the Spigelian lobe itself being situated behind the small omentum, and projecting into the omental sac. The *square* lobe ([3], lobulus anonymus, lobulus quadratus) is that part which is situated between the gall-bladder ([10]) and the great longitudinal fissure, and in front of the fissure for the portal vein.

[Fig. 461.



The under surface of the liver. 1. The right lobe. 2. The left lobe. 3. The lobus quadratus. 4. The lobus Spigelii. 5. The lobus caudatus. 6. The longitudinal fissure; the numeral is placed on the rounded cord, the remains of the umbilical vein. 7. The pons hepatis. 8. The fissure for the ductus venosus; the obliterated cord of the ductus is seen passing backwards to be attached to the coats of the inferior vena cava (9). 10. The gall-bladder lodged in its fossa. 11. The transverse fissure, containing, from before backwards, the hepatic duct, hepatic artery, and portal vein. 12. The vena cava. 13. A depression corresponding with the curve of the colon. 14. A double depression produced by the right kidney and its supra-renal capsule. 15. The rough surface on the posterior border of the liver left uncovered by peritoneum; the cut edge of peritoneum surrounding this surface forms part of the coronary ligament. 16. The notch on the anterior border, separating the two lobes. 17. The notch on the posterior border, corresponding with the vertebral column.—W].

The Fissures.—Of the five *fissures* or *fossæ* of the liver, which are seen on its under surface only, all are not of equal significance. 1. The *transverse* fissure, or *portal* fissure ([11]), is the most important, because it is here that the great vessels and nerves enter, and the hepatic duct passes out. It is situated across the middle of the right lobe, somewhat nearer to its posterior than its anterior border, occupying its inner half only, and meeting nearly at right angles with the

longitudinal fissure. It is bounded in front by the square lobe ([3]), and behind by the Spigelian lobe ([4]) and the caudate lobe ([5]). These boundaries were compared to the *pillars* of a *gate*, the fissure itself being likened to a gateway, *porta;* and hence the large vein to which it gives admission was named *vena portæ*, or *vena portarum*. Besides this vessel, the hepatic artery and nerves and the hepatic duct and principal lymphatics enter or pass out at the transverse fissure, which has therefore been termed the *hilus* of the liver. 2, 3. The *longitudinal* fissure, which separates the right and left lobes of the liver from each other, is divided into two parts by its meeting with the transverse fissure. The anterior part, named the *umbilical* fissure, contains the umbilical vein in the fœtus, and the remains of that vein in the adult, which then constitutes the round ligament. It is situated between the square lobe and the left lobe of the liver, the substance of which often forms a bridge ([7]) across the fissure, so as to convert it partially or completely into a canal. The posterior part ([8]) is named the *fissure* of the *ductus venosus* (fossa ductus venosi); it continues the umbilical fissure backwards between the lobe of Spigelius and the left lobe; and it lodges the ductus venosus in the fœtus, and in the adult a slender cord or ligament into which that vein is converted. 4. The *fissure* or *fossa* of the *vena cava* is situated at the back part of the liver, between the Spigelian lobe on the left and the right lobe on the right, separated from the transverse fissure by the caudate lobe. It is continued upwards in an oblique direction on to the posterior border of the liver, and may almost be said to join behind the Spigelian lobe with the fissure for the ductus venosus. It is at the bottom of this fossa that the blood leaves the liver by the hepatic veins, which end here in the vena cava. The substance of the liver in some cases unites around the vena cava, and encloses that vessel in a canal. 5. The last remaining fissure, or rather, *fossa*, (fossa cystis felleæ,) is that for the lodgment of the gall-bladder ([10]): it is sometimes continued into a slight notch on the anterior margin of the liver.

Besides these, there are two shallow impressions on the under surface of the right lobe: one in front (*impressio colica*), ([13]) corresponding with the hepatic flexure of the colon; and one behind (*impressio renalis*), ([14]) corresponding with the right kidney.

Vessels and Ducts.—1, 2. The two vessels by which the liver is supplied with blood are the hepatic artery and the vena portæ. The *hepatic artery*, (fig. 246, *d*,) a branch of the cœliac axis, is intermediate in size between the other two branches of that trunk, being larger than the coronary artery of the stomach, but not so large as the splenic artery. It is, therefore, a small vessel in comparison with the size of the organ to which it is distributed. It enters the transverse fissure, and there divides into a right and left branch, for the two principal lobes of the liver. Sometimes there is an hepatic branch, derived from the coronary artery of the stomach or from the superior mesenteric. The coats of the liver also receive small vessels from other sources, as from the branches of the phrenic, internal mammary, and epigastric arteries.

By far the greater part of the blood which passes through the liver,

—and this is its chief peculiarity as a gland,—is conveyed to it by a large vein, the *vena portæ* (fig. 263, *a*). This vein is formed by the union of nearly all the veins of the chylopoietic viscera, viz., those from the stomach and intestines, the pancreas and spleen, omentum and mesentery, and those from the gall-bladder also. It enters the *porta*, or transverse fissure, where, like the hepatic artery, it divides into two principal branches.

3. The *bile-duct* or *hepatic* duct is, also, formed by the union of a right and left branch, which issue from the bottom of the transverse fissure, and soon unite at a very obtuse angle. (Figs. 263 and 473.)

The three vessels above mentioned ascend to the liver between the layers of the gastro-hepatic omentum, above the foramen of Winslow, and thus reach the transverse fissure together. Their relative position is as follows:—The bile-duct is to the right, the hepatic artery to the left, and the large portal vein is behind and between the other two. They are accompanied by numerous lymphatic vessels and nerves, and are surrounded by a cellular tissue named the capsule of Glisson. The branches of these three vessels accompany one another in their course through the liver nearly to their termination; and in this course are surrounded by a common investment (Glisson's capsule), which is prolonged into the interior of the organ.

4. The *hepatic veins*, which convey the blood out from the liver, pursue an entirely different and independent course through its substance, and pass out at its posterior border, where, at the bottom of the fossa already described, they end by two principal branches, besides other smaller ones, in the vena cava.

5. The last order of vessels belonging to the liver are the *lymphatics*. They are large and numerous, and form a deep and a superficial set. The deep lymphatics accompany the vessels in the portal canals, to be presently described, and emerge at the transverse fissure. The superficial set form a network on the upper and under surfaces of the organ, and communicate freely with each other and also with the deep set.

Nerves.—The *nerves* of the liver are derived partly from the cœliac plexus, and partly from the pneumogastric nerves, especially from the left pneumogastric. They enter the liver supported by the hepatic artery and its branches; along with which they may be traced a considerable way in the portal canals, but their ultimate distribution is not known.

Structure of the Liver.

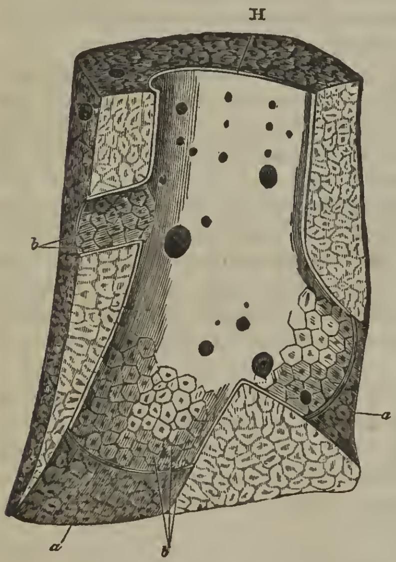
Coats.—The liver has two coverings, viz., a serous coat and a proper cellular coat. The *serous* coat, smooth, moist, shining, and transparent, is derived from the peritoneum, and covers every part of the free surface of the gland; but it is deficient at the part of the liver round which the suspensory, coronary, and two lateral ligaments are reflected to the diaphragm, and also at the bottom of the several fissures or fossæ, especially those for the vena portæ, vena cava, and gall-bladder. It adheres closely to the proper or cellular coat.

The *cellular* or *fibrous* coat, as it is also called, invests the whole

gland. Opposite to the parts covered by the serous coat it is thin and difficult to demonstrate; but where the peritoneal coat is absent, as at the posterior border of the liver, and in the portal fissure, it is denser and more evident. Its inner surface is attached to the hepatic glandular substance, being there continuous with the delicate cellular tissue between the lobules of which the gland is composed. At the transverse fissure it becomes continuous with the capsule of Glisson.

The *proper substance* of the liver, which has a reddish brown colour and a mottled aspect, is compact, but not very firm. It is easily cut or lacerated, and is not unfrequently ruptured during life from accidents, in which other parts of the body have escaped injury. When the substance of the liver is torn, the broken surface is not smooth but minutely granular, and this is owing to the fact of its being composed of a multitude of small masses called *lobules* (fig. 462). These lobules vary from half a line to nearly a line in diameter; they are closely packed polyhedral bodies, about the size of a pin's head, which are held together by fine cellular tissue, and by the blood-vessels and ducts. This interlobular tissue is continuous with the fibrous coat on the exterior of the liver, and also with the capsule of Glisson within the portal canals. Such, at least, are the views entertained by Mr. Kiernan.* Some anatomists of authority, as Weber and Krukenberg, while they admit the existence of fissures between the lobules to give passage to the vessels, deny that the lobules are completely insulated, believing that they coalesce at different points. After a second investigation of this point, Müller still adheres to the opinion of Mr. Kiernan.† On the surface of the liver the lobules are triangular, and more or less flattened on their exposed surface; but deeper within the substance of the gland, they have usually four or five sides. They are all compactly arranged around the sides of certain branches of the hepatic veins (H), each lobule resting by a smooth surface, or *base*, upon the vein, and being connected with it by a small venous trunk (*b*), which arises in the centre of the lobule, and passes out from the middle of its base to end in the larger subjacent vessel. The

Fig. 462.



H, longitudinal section of an hepatic vein; *a*, *a*, portions of the canal from which the vein has been removed; *b*, *b*, orifices of intralobular veins. The large orifices opening into the hepatic vein are the mouths of the sublobular veins. (After Kiernan.)

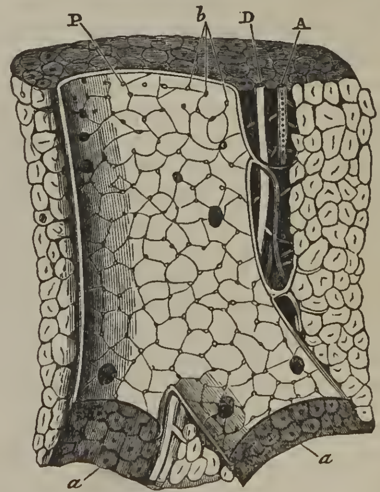
* Philosoph. Transactions, 1833, vol. ii. † Archiv, 1843.

small veins proceeding from the centre of the lobules are named the *intralobular* veins (*b*) and those on which the lobules rest, the *sublobular* veins. If one of these sublobular veins be opened, the bases of the lobules (*b*) may be seen through the coats of the vein, which are here very thin, forming a tessellated appearance, each little polygonal space representing the base of a lobule, and having in its centre a small spot, which is the mouth of the intralobular vein. When divided in the direction of a sublobular vein, the attached lobules present a foliated appearance, for that part of their surface which is not in contact with the vein is itself slightly lobulated or developed into blunt processes. Cut in a transverse direction, they present a polyhedral form. (Fig. 463.)

The *hepatic* veins, which may now be traced, commence in the centre of each lobule by the union of its capillary vessels into a single independent intralobular vein. (Fig. 464,[1].) These minute intralobular veins, (fig. 462, *b*) open at once into the sides of the subjacent sublobular veins. The sublobular veins are of various sizes, and anastomose together. Uniting into larger and larger vessels, they end at length in another kind of hepatic venous trunks (H), which receive no intralobular veins. Lastly, these venous trunks, converging towards the posterior border of the liver, and receiving in their course other small sublobular veins, terminate in the vena cava, at the bottom of the fossa already described. In this course, the hepatic veins and their successive ramifications are unaccompanied by any other vessel. Their coats are extremely thin; the sublobular branches adhere immediately to the lobules, and even the larger trunks have but a very slight cellular investment, which connects them to the substance of the liver. Hence the divided ends of these veins are seen upon a section of the liver as simple open orifices, surrounded closely by the solid substance of the gland (*a*, *a*).

2. The vena portæ and hepatic artery, which, together with the biliary ducts, enter the liver at the transverse fissure, have a totally different course, arrangement, and distribution from those of the hepatic vein. Within the liver the branches of these three vessels lie together in certain canals, called *portal canals*, which are tubular passages formed in the

Fig. 463.



Section of a portal canal and portal vein lying in it, in company with the hepatic artery and duct. (Kiernan.) P. Branch of vena portæ, situated in *a*, *a*, a portal canal, formed amongst the lobules of the liver. The large orifices opening into the portal vein are the mouths of the vaginal branches. *b*. Orifices of interlobular veins arising at once from the large vein. A. Hepatic artery. D. Hepatic duct.

substance of the gland, commencing at the transverse fissure, and branching upwards from that part in all directions. Each portal canal (even the smallest) contains, as shown in a longitudinal section (fig. 463), one principal branch of the vena portæ (P), of the hepatic artery (A), and of the biliary duct (D); the whole being invested by the continuation, along the canals, of the cellular sheath named Glisson's capsule. This arrangement of the parts is rendered evident by making a cross section of a portal canal, when the large orifice of the portal vein, accompanied by the biliary duct (of much smaller size) and a branch of the hepatic artery, which is the smallest of the three, are seen, surrounded by a web of cellular tissue, which separates them from the substance of the liver.

The *portal* veins (P), as they lie in the portal canals, give off lateral branches, named *vaginal* veins, which ramify and form a plexus in Glisson's capsule, and then send off smaller branches, called *interlobular* veins, which enter between the lobules (fig. 464, [2 2]), and, after ramifying freely, and, according to Kiernan, anastomosing, penetrate the surface of the lobules themselves, and end in a capillary network within them. From this network the intralobular (hepatic) vein of each lobule ([1]) takes its origin. In the smaller portal canals the vaginal veins and plexuses are less evident, for many of the intralobular veins (as at *b*, fig. 463) arise at once from the principal branch (P) of the vena portæ. In the smaller canals, too, the capsule of Glisson is very thin, as if its office were no longer needed; for (like the periosteum and pia mater) it seems principally to be required as a tissue in which the vessels may divide into smaller branches before they enter the structure which they have to supply.

The *hepatic* artery (A) also gives off its *vaginal* and *interlobular* branches. These are distributed to the coats of the various vessels, (especially to the ducts, which become very red in a successful injection,) to the capsule of Glisson, the interlobular cellular tissue, and the proper coat of the liver (*rami vasculares, rami capsulares*). There are but few of its branches between the lobules, and still fewer have been found within their margin. Kiernan believes that the branches of the hepatic artery terminate in a system of capillary vessels, from which the blood is collected and conveyed into the portal veins, by means of small venous radicles, which may be considered as intrahepatic tributary branches of the vena portæ, analogous to the superior mesenteric, the splenic, the cystic, and other extra-hepatic branches or roots of that great vein. The blood from the hepatic artery, therefore, reaches the hepatic veins only indirectly through the intervention of the vena portæ.

This opinion, which was also that of Ferrein,* and is now supported by Theile,† is opposed to the view that the hepatic artery and vena portæ communicate by means of a common capillary system, with the hepatic veins,—an opinion still maintained by several anatomists of authority.

* Ferrein, Mém. de l'Acad. des Sciences, 1733.

† Theile, Hand-Wörterbuch der Physiologie, (Wagner's,) p. 342.

The branches of the *hepatic ducts* (D) have been traced emerging from the surface of the lobules ([2], fig. 465), and forming between them an interlobular plexus of ducts. Branches from this plexus enter the portal canals as *vaginal* branches, and there unite into larger and larger ducts, which do not anastomose. There is always one principal duct in each portal canal.

Structure of the Lobules.—From what has preceded, the arrangement of the blood-vessels within each lobule will be readily understood. The ultimate branches of the vena portæ (fig. 464, [2], [2],) having ramified upon the surface of a lobule, enter it at all points, and form a plexus within it, composed of radiating and transverse connecting vessels. These having become reduced by division and subdivision to a capillary size, form a network from which arise the commencing radicles of the intralobular hepatic vein in the centre ([1]).

Fig. 464.

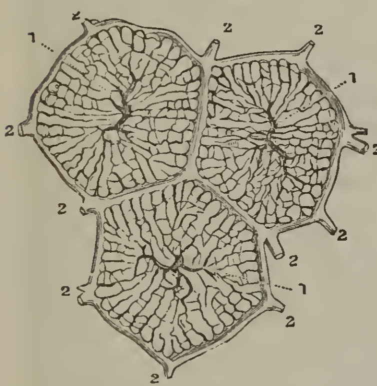


Fig. 465.

Fig. 464. Diagram showing the arrangement of the blood-vessels within and between the lobules. (Kiernan.) 2, 2. Interlobular branches of portal vein, forming the intralobular venous plexus, connecting the portal veins (2, 2) with the intralobular vein (1) in the centre, which is the commencing branch of the hepatic vein.

Fig. 465. 2, 2. Branches of the hepatic duct, which is supposed to commence in a plexus situated towards the circumference of the lobule called by Kiernan the biliary plexus. Within this is seen the central part of the lobule, containing branches of the intralobular (hepatic) vein (1).

As already stated, opinions are still divided as to the relations of the capillaries of the hepatic artery to the capillary network within the lobules. From the ultimate distribution of the branches of the vena portæ, it is evident that the blood of that vessel is largely concerned in the secretion of the bile. The hepatic artery, on the other hand, is essentially the nutrient vessel of the constituent parts of the gland, and its blood either previously enters the portal system as suggested by Kiernan, and thus as portal blood assists in the secretion of the bile, or, as supposed by others, it reaches the capillary system of the lobules in the condition of arterial blood.

The distribution of the portal and hepatic veins within the lobules, as just described, has suggested an explanation of the mottled aspect of the liver, an appearance which has led to the erroneous idea of there being two substances in each lobule, one darker than the other. The colour of the hepatic substance is pale yellow, and would be uniform throughout, were it not varied according

to the quantity of blood contained in its different vessels. Thus, if the system of hepatic veins be congested, the centre of each lobule is dark, and its margin pale: this is the common case after death, and is named by Mr. Kiernan *passive* congestion. In what is considered an *active* state of hepatic congestion, the dark colour extends to the portal system, across the interlobular fissures, leaving intermediate spaces, which remain as irregular pale spots: this state occurs especially in diseases of the heart. When, on the other hand, the portal system is congested, which is rare, and occurs generally in children, the margins of the lobules are dark, and their centres pale.

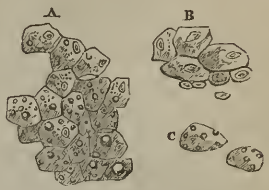
The interstices between the blood-vessels in each lobule are occupied by the commencement of the biliary *ducts*, and they also contain a peculiar substance (the *hepatic substance*), composed of numerous microscopic nucleated corpuscles. These corpuscles present specific characters; they are evidently concerned in the secretion of the bile, and are named the *hepatic cells* or *corpuscles*.

Ducts.—According to Mr. Kiernan the biliary ducts (fig. 465,[2]) commence within the lobules by numerous ramifications, which form a closed network or plexus, occupying principally the outer portion of each lobule. The anastomosis of the ducts was doubted by Müller, who, having observed that in the lower animals, and also in the embryo of birds, the biliary ducts terminate in tufts of tubes, having free and blind extremities, thought it probable that a similar structure existed in the human liver. Since the discovery of the hepatic cells, both of these views have undergone considerable modification in the opinion of anatomists. Thus, it is conceived by Krukenberg and Theile that the interstices between the network of capillary blood-vessels in the lobules represent the reticular ducts of Kiernan; and, further, that these interstices or ducts are lined, and in a manner filled by the secreting nucleated hepatic cells. It has been questioned whether these intervascular spaces are bounded by a proper limitary or constituent membrane, or whether the nucleated cells lie in immediate contact with the coats of the capillaries; but the former opinion is on the whole the more probable. It has been further noticed, first by Dujardin and Berger, and afterwards by Henlé, Müller, and others, that the nucleated cells lie in linear series between the vessels, and for the most part present a similar radiated arrangement from the centre towards the margin of the lobules. E. H. Weber conceived that a single file or row of these cells was contained in each of the finest ducts, or rather formed the tubular cavity of such a duct by successively opening into each other. Henlé conceives that the commencing ducts are mere interstitial channels in a mass of cells filled with bile, and that these nascent and imperfect ducts pass into others, which have a distinct bounding membrane and lining epithelium. He supposes that the bile either exudes from the cells into the intercellular channels, or escapes into these channels by the destruction or solution of the adjoining cells, which give place to others successively undergoing the same process. Other anatomists, again, as Theile, suppose that ducts do not exist at all as such within the lobules, but commence upon their outer surface; and that the secreted bile either finds its way into them by oozing through and between the nucleated cells, or is introduced into them by rupture and subsequent intercommunication

of the cells, which is said to take place in succession along the rows of cells which radiate from the centre to the margin of a lobule.

The hepatic cells.—These are nucleated cells of a spheroidal, compressed, or polyhedral form, (fig. 466, A,) having a mean diameter of from $\frac{1}{1080}$th to $\frac{1}{840}$th of an inch; according to Henlé they are some of them only $\frac{1}{1716}$th of an inch in diameter. They present some colour even when highly magnified, being of a faint yellowish hue. They usually include a very clear bright nucleus of a rounded form, within which again one or two nucleoli may be seen. The cells also contain very fine granular or vesicular molecules. In many cases, too, the cells of the human liver and of that of quadrupeds have larger and smaller semi-transparent fat-globules in their interior. Their nucleus is frequently quite indistinguishable; and sometimes, on the other hand, cells are observed which are provided with two separate nuclei. As already stated, they lie in rows or streaks amongst the vessels, radiating from the centre of the lobules towards their circumference.

Fig. 466.



Hepatic cells. (Dr. Baly.)—A. From healthy human liver. B. From a case of supposed cirrhosis. C. From the sheep's liver.

Aberrant biliary ducts.—In the duplicature of the peritoneum forming the left lateral ligament of the liver, and also in the two fibrous bands which sometimes convert the fossa for the vena cava and the fissure of the umbilical vein into canals, there have been found biliary ducts of tolerable size which are not surrounded with lobules. These aberrant ducts, as they might be called, are described by Ferrein and by Kiernan: they anastomose together in form of a network, and are accompanied by branches of the vena portæ, hepatic artery, and hepatic vein.

["In vertebrated animals the liver is of large size, and of no general regular form. It is usually divided by deep fissures into several portions or lobes, which are invested by the peritoneum. In colour it passes through all the shades of light pink or nearly white, yellow, red, brownish purple, and brown. When the surface is closely examined beneath the transparent peritoneum, it will be found to have somewhat the appearance of a mosaic structure, a dark ground inlaid with small portions of a lighter colour. In intimate structure it consists of numerous, small, irregular bodies, or lobules (lobules of Kiernan), corresponding to the lighter portions just mentioned, which are lobulated themselves and closely connected together by means of white and yellow fibrous tissue and the blood-vessels belonging to the organ, which correspond to the dark ground-lines separating the lighter-coloured masses. The lobules are not regularly arranged side by side throughout the liver, but lie in all directions, principally, however, with their long diameters at right angles to the surfaces. When the vessels of a liver have been injected, and the organ then hardened in alcohol so that it may be rendered more consistent and its difference of structure more perceptible, and a section made at right angles to the surfaces of the organ, a view like fig. 467, will be obtained. In such a section, lobules will be observed to be cut in all directions: longitudinally, when they have a foliated appearance; obliquely or transversely, when they have a more or less polygonal form, depending upon the amount of mutual pressure at any part of the liver, being greatest in the interior, least near the surface. In their interior, sections of blood-vessels are seen, which belong to the hepatic veins; and the vessels occupying the interspaces between them are branches of the hepatic artery and the vena portarum. The lobules are composed

Fig. 467.

Fig. 468.

Fig. 467. Longitudinal section of human liver from the posterior part near the upper surface, magnified 3 diameters, from a preparation made by Dr. Horner. The three sets of blood-vessels were injected with colouring matter and the preparation then preserved in alcohol. The blood-vessels represented in the drawing belong to the hepatic veins, and are seen at various parts coming from the interior of the lobules. The spaces between the lobules, which are filled with branches of the hepatic artery and vena portarum and hepatic ducts, have been purposely left white, so as not to obscure the view of the lobules.

Fig. 468. Transverse section of a lobule of the human liver, taken from the same preparation as fig. 467, highly magnified, and presenting to view the reticulated structure of the biliary tubes. In the centre of the figure is seen the hepatic vein cut across and several small branches terminating in it. Where the injecting matter did not run freely, it is seen standing in dots along the course of the vessels. At the periphery are seen branches of the hepatic artery, vena portarum and hepatic duct.—J. L.]

of an intertexture of biliary tubes, (pori biliari,) (fig. 468,) and in the areolæ or interspaces of the network the blood-vessels ramify and form amongst themselves an intricate anastomosis, the whole being intimately connected together by a combination of the white fibrous and yellow elastic tissue.

"In structure the biliary tubes (figs. 469, 470) correspond with those of the in-

[Fig. 469.

Fig. 470.

Fig. 469. A small portion of fig. 468 more highly magnified. The secreting cells are seen within the tubes, and in the interspaces of the latter the fibrous tissue is represented.

Fig. 470. Portion of a biliary tube, from a fresh human liver, very highly magnified. The secreting cells may be noticed to be polygonal from mutual pressure.—J. L.]

vertebrata, consisting of cylinders of basement membrane containing numerous secreting cells, and the only difference exists in the arrangement; the free tubes of the invertebrata, in the vertebrata becoming anastomosed or forming an intertexture. The tubuli vary in size in an unimportant degree in different animals, and also in the same animal, being generally from two to two and a half times the diameter of the secreting cells. The tubes of one lobule are distinct from those of the neighbouring lobuli, or only communicate indirectly by means of the trunks or hepatic ducts originating from the tubes and lying in the interspaces of the lobuli. The secreting cells are irregularly angular, or polygonal in form from mutual pressure, and line the interior surface of the tubes. They vary in size in a moderate degree in different animals and also in the same animal, appearing to depend upon certain conditions of the animal and liver. The colour is light yellowish, or brownish when in mass, the other and darker colours of the liver appearing to depend upon the blood in the organ. They contain a finely granular matter, oil-globules, a granular nucleus, and a transparent nucleolus.

"The finely granular matter is the portion from which the colour of the cell is derived; it appears to be made up of innumerable exceedingly minute spheriform granules, which, when under a low power of the microscope and well defined, look like so many minute black points. This substance, from its quantity and minute state of division, often obscures the nucleus so that it cannot be distinguished until acetic acid is applied to it, when it is rendered more translucent without affecting the nucleus. The oil or fat varies in quantity in different conditions of the liver, and in different cells. It exists in the form of exceedingly minute globules, looking like so many intensely black points, and hardly perceptible from the granular contents of the cells, up to larger and distinct globules, sometimes one-fourth the diameter of the cell. From the gradual advance from a state hardly distinguishable from the granular matter of the cells up to a large size, and in the invertebrata even to a distended state of the cell, a gentleman, to whom I presented the observation, supposed that the liver only secreted fatty matter, while the gall-bladder secreted cholesterine, the latter fact being presented to his observation in several pathological cases, in which the cystic duct was obstructed and the bladder filled with white concretions (biliary calculi), which consisted of pure cholesterine. This, which appears plausible at first view, falls at once to the ground when it is recollected that some animals have no gall-bladder, as the horse, sloth, &c., and yet secrete a bile constituted like that of animals possessing a gall-bladder. The giraffe, it is also well known, in the three or four cases in which the animal has been dissected, in two cases had no gall-bladder, and in a third instance possessed one of large size. I have mentioned that the quantity of oil-globules varies in different conditions of the animal or organ. If the animal be very fat, or be well fed, especially on substances containing much starch, it will be found in greater abundance than usual; as may be readily seen in the difference between poultry which run about and those which are penned up for fattening; and I have no doubt that in the preparation of the liver of geese, in which it becomes enormously enlarged, for making the '*paté de foie gras de Strasbourg*,' there is not the addition of a single secreting cell, but merely an accumulation of fat globules, within the secreting cellules, derived indirectly from the starchy matters of the food, which ordinarily are consumed in the process of respiration. In phthisis, in which more or less of the respiratory surface is destroyed, the liver appears to take upon itself part of the office of the lungs, but rids the blood of the excess of carbon in another way, that is, by converting it, with the elements of water, into fat, which is deposited within the cells, producing what is called "fat liver." The same condition of the liver is produced in drunkards, probably from the stimulation to nutrition and the conversion of the alcoholic constituents into fat.

"The nucleus is generally central, frequently lateral, globular, and pretty uniform in size in the same animal. It is granular in structure and never contains oil-globules; generally, it is but indistinctly seen, excepting in fishes and reptiles, and frequently not at all, from the granular contents of the cell obscuring it, but is readily brought into view by the influence of acetic acid upon the latter. Sometimes there are two nuclei instead of one.

"The nucleolus measures about ·001 millimetre, is round in form, consistent, and transparent, and is situated in the centre of the nucleus.

"The interlobular trunks or commencement of the hepatic ducts, as they originate from the biliary tubes or pores, run in varied direction in regard to the lobules, and freely anastomose with each other, and by their convergence form trunks which take a general course at right angles to the surfaces of the liver, and finally appear by several trunks externally beneath the liver.

"The blood-vessels of the liver consist of two sets, the hepatic artery and vena portarum, which convey the blood to it, and a third set, the hepatic veins, which conduct the effete blood from it into the general circulation again.

"The hepatic artery, much smaller than the vena portarum, appears to be appropriated to the nutrition and supply of oxygen to the tissues entering into the composition of the liver; while the vena portarum is probably devoted to the conveyance of blood to the secreting cells, which appropriate the peculiar fluid of the liver, or bile from it. These two vessels enter the liver at the place of exit of the hepatic ducts, and follow the same course inwards that the latter did in coming out. The artery in its passage supplies the duct with branches and the vena portarum with vasa vasorum. In the intervals of the lobules they comport themselves very much in the manner of the interlobular ducts, and form an intricate network around the lobules, but whether the two sets of vessels anastomose I could not satisfactorily determine. They both send off numerous branches, which enter the lobules at right angles to the length of the latter, and form an intricate plexus by turning through the interspaces of the biliary tubes. The vessels within the lobules freely communicate with each other and converge towards their interior, where they terminate in trunks, which run in the length of the lobules, and are the commencement of the hepatic veins. This free intercommunication of the three sets of vessels within the lobules has been fairly proved to me by a minute injection of a young liver, made by Dr. Horner, and preserved in the Wistar Museum.

"The commencing branches of the hepatic veins issue from the base of the lobules, and by their convergence, form several large trunks, which pass out of the liver at right angles to the other two sets and parallel to its surfaces, at its dorsal margin close to the spinal column."—J. L.]*

THE BILE.

The bile, as it flows from the liver, is a thin greenish yellow fluid; but that which remains in the gall-bladder becomes darker, more viscid, and ropy. It contains as adventitious particles mucus and epithelium corpuscles. The specific gravity of the bile is from 1·026 to 1·030. It has a sweetish bitter taste, and an alkaline reaction. It is a saponaceous compound, containing the following ingredients :—water, mucus, colouring matters (composed, according to Berzelius, of a yellow substance named cholepyrrhine, a brown substance named bilifulvine, and a green matter or biliverdine), fatty acids, viz., the margaric and oleic, combined with soda, free fat, cholesterine, salts, and, lastly, the most important ingredient of the bile, namely, choleic or bilic acid, a resinous or fatty acid, which is also in a state of combination with soda. This choleic acid consists principally of carbon and hydrogen, but it also contains nitrogen and sulphur; it is very easily decomposed, and gives rise to ammoniacal and other compounds.

THE EXCRETORY APPARATUS OF THE LIVER.

The excretory apparatus of the liver consists of the hepatic duct, the cystic duct, the gall-bladder, and the common bile-duct, or ductus communis choledochus.

The *hepatic* duct, (fig. 473,) commencing at the transverse fissure of the liver, descends to the right, within the gastro-hepatic omentum, in front of the vena portæ, and to the right of the hepatic artery. Its

* [Researches into the Comparative Structure of the Liver, by Joseph Leidy, M.D., Amer. Jour. of Med. Science, Phil. Jan. 1848.—J. L.]

diameter is about two lines, and its length nearly two inches. At its lower end it meets with the cystic duct, coming down from the gall-bladder; and the two ducts uniting together at an acute angle, form the ductus communis choledochus (*f*).

The *gall-bladder* (*g*) is a pear-shaped membranous sac, about three or four inches long, rather more than an inch across at its widest part, and capable of containing about eight or ten fluid-drachms. It is lodged obliquely in a fossa on the under surface of the right lobe of the liver, so that its large end or *fundus*, which projects beyond the anterior border of the gland, is directed downwards, forwards, and to the right, whilst its body and narrow end or *neck* are inclined in an opposite direction, viz., upwards, backwards, and to the left.

The *upper surface* of the gall-bladder is attached to the liver by cellular tissue and vessels, along the fossa formed between the square lobe and the remainder of the right lobe. Its *under surface* is free and covered by the peritoneum, which is here reflected from the liver, so as to include and support the gall-bladder from below. Sometimes, however, the peritoneum completely surrounds the gall-bladder, which is then suspended by a kind of mesentery at a little distance from the under surface of the liver. The *fundus* of the gall-bladder, which is free, projecting, and always covered with peritoneum, touches the abdominal parietes immediately beneath the margin of the thorax, opposite the tip of the tenth costal cartilage. Below, it rests on the commencement of the transverse colon; and, further back, the gall-bladder is in contact with the duodenum, and sometimes with the pyloric extremity of the stomach. In consequence of these relations with the hollow viscera and with the surface, gall-stones occasionally make their way from the gall-bladder into the intestines, or even externally, by a process of adhesion and ulcerative absorption. The *neck* of the gall-bladder, which is gradually narrowed, forms two curves upon itself like an S, and then, having become much constricted, and changing its general direction altogether, bends downwards and terminates in the cystic duct.

Structure.—Besides the peritoneal investment, the gall-bladder has two distinct tunics, viz., a cellular and a mucous coat.

The *cellular* coat is strong, and consists of bands of dense shining white fibres, which interlace in all directions. These fibres resemble those of cellular tissue; and, as a matter of inference only, they are supposed to possess contractility. In recently killed quadrupeds the gall-bladder contracts on the application of a stimulus; and in the larger species, such as the ox, muscular fibres of the plain variety have been found in this coat. It forms the framework of the organ, and supports the larger blood-vessels and lymphatics.

The *mucous* coat, which is generally strongly tinged of a yellowish brown colour with bile, is elevated upon its inner surface into innumerable ridges, which, uniting together into meshes, leave between them depressions of different sizes and of various polygonal forms. This structure gives to the interior of the gall-bladder an areolar aspect, which is similar to what is seen on a smaller scale in the vesiculæ seminales. These areolar intervals become smaller towards the fundus

and neck of the gall-bladder; and at the bottom of the larger ones, other minute depressions, rendered visible by a lens, apparently lead into numerous mucous recesses or follicles. The whole of the mucous membrane is covered by columnar epithelium, and it secretes an abundance of viscid mucus.

At the points where the neck of the gall-bladder curves on itself, there are strong folds or projections of its mucous and cellular coats into the interior.

The gall-bladder is supplied with blood by the *cystic* branch of the right division of the hepatic artery, along which vessel it also receives nerves from the cœliac plexus. The cystic veins empty themselves into the vena portæ. The lymphatics join those of the liver.

The gall-bladder is a receptacle or reservoir for such bile as is not immediately required in digestion. The bile contained within it becomes darker and inspissated, receiving some addition of mucus, and becoming more ropy and viscid, but beyond this it undergoes no further change.

The *cystic duct* is about an inch or rather more in length. It runs downward and to the left, thus forming an angle with the direction of the gall-bladder, and unites with the hepatic duct to form the ductus communis. In its interior, the mucous membrane is elevated in a singular manner into a series of crescentic folds, which are arranged in an oblique direction, and succeed closely to each other, so as to present very much the appearance of a continuous spiral valve. When distended, the outer surface of the duct appears to be indented in the situation of these folds, and dilated or swollen in the intervals, so as to present an irregularly sacculated or twisted appearance.

The *common bile-duct* (fig. 473, *f: ductus communis choledochus*), the largest of the three ducts, being from two to three lines in width, and nearly three inches in length, conveys the bile both from the liver and the gall-bladder into the duodenum. It continues downwards and backwards in the course of the hepatic duct, between the layers of the gastro-hepatic omentum, in front of the vena portæ, and to the right of the hepatic artery. Having reached the descending portion of the duodenum, it continues downwards on the inner and posterior aspect of that part of the intestine, covered by or included in the head of the pancreas, and, for a short distance, in contact with the right side of the pancreatic duct. Together with that duct, it then perforates the muscular wall of the intestine, and after running obliquely for three-quarters of an inch between its several coats, and forming an elevation beneath the mucous membrane, it becomes somewhat constricted, and opens by a common orifice with the pancreatic duct on the inner surface of the duodenum, at the junction of the second and third portions of that intestine, and rather more than three inches below the pylorus.

Structure.—The structure of all the bile-ducts is alike. Their cellular coat is strong and distensible. The mucous membrane is provided with numerous glands, the openings of which are scattered irregularly in the larger ducts, but in the small subdivisions of the hepatic duct are arranged in two longitudinal rows, one at each side of the vessel.

The mouths of these glands have been long known, and were supposed to be merely the openings of mucous follicles; but the structure of the glands of the biliary ducts has been recently found by Theile to be more complicated. According to his observations, which we have been able to confirm, some of them are ramified tubes, which occasionally anastomose together, and often present lateral saccular dilatations similar to the Meibomian glands. Others, again, which are more solid and clustered together, are little cellular glands opening into the bile-duct by a single orifice. Sometimes these cellular glands are attached to the tubular glands, and open into them.

Development.—According to some the gall-bladder is developed as a branch or diverticulum from the bile-duct outside the liver; but Meckel says it arises in a deep notch in the substance of the gland. It is at first tubular, and then has a rounded form. The alveoli in its interior appear about the sixth month. At the seventh month it first contains bile. In the fœtus its direction is more horizontal than in the adult.

Varieties in the excretory apparatus of the liver.—The gall-bladder is occasionally wanting; in which case the hepatic duct is much dilated within the liver, or in some part of its course. Sometimes the gall-bladder is irregular in form, or is constricted across its middle, or, but much more rarely, it is partially divided in a longitudinal direction. Direct communications by means of small ducts, (named hepato-cystic,) passing from the liver to the gall-bladder, exist regularly in various animals; and they are sometimes found, as an unusual formation, in the human subject.

The right and left divisions of the hepatic duct sometimes continue separate for some distance within the gastro-hepatic omentum. Lastly, the common bile-duct not unfrequently opens into the duodenum, apart from the pancreatic duct.

DEVELOPMENT AND FŒTAL PECULIARITIES OF THE LIVER.

The liver begins to be formed at a very early period of fœtal life. Its development has been traced in the bird (fig. 471) from a conical protrusion of the intestinal canal (*c*), surrounded by a soft mass or blastema (*d*), in which, by a subsequent process of growth, the ducts are formed. In the mammalian embryo (the dog) it has been found by Bischoff to commence by a double mass of blastema attached to the outer wall of the intestinal tube immediately beneath the dilatation for the stomach, and having a conical protrusion of the internal membrane passing into each division of the mass. In a very early condition, ramified lines or commencing ducts may be seen as in other glands; but this appearance is not afterwards visible, owing to the thickness and colour of the gland, and also in consequence of the development of nucleated cells.

Size.—In the human fœtus, at the third or fourth week, the liver is said to constitute one half the weight of the whole body. This proportion, however, gradually decreases as development advances, until at the full period the relative weight of the fœtal liver to that of the body is as 1 to 18.

In the early fœtus the right and left lobes of the liver are of equal, or nearly equal, size; and just before birth the difference between them is not great, the relative weight of the left lobe to the right being nearly as 1 to 1·6.

Position.—In consequence of the greater equality as to size between the two lobes, the position of the fœtal liver in the abdomen is more symmetrical, as regards the middle line of the body. In the very early fœtus it occupies nearly the whole of the abdominal cavity; and at the full period it still descends an inch and a half below the margin of the thorax, overlaps the spleen on the left side, and reaches nearly down to the crest of the ilium on the right.

Form, Colour, &c.—The fœtal liver is thicker from above downwards, and has therefore a rounder form than in the adult. It is generally of a darker hue. Its consistence and specific gravity are both less than in the adult.

Blood-vessels.—Lastly, the blood-vessels of the fœtal liver present most important peculiarities, with which, indeed, all those previously mentioned are more or less connected.

Fig. 471.

Fig. 472.

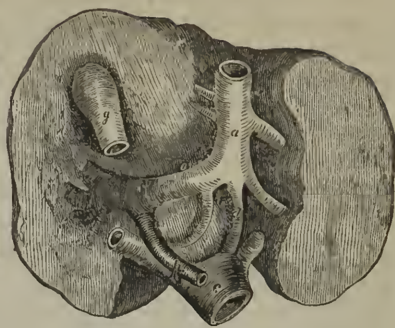


Fig. 471. Early condition of the liver in the chick at the fifth day of incubation. (Müller.)—*a.* The heart, as a simple curved tube. *b.* The intestinal tube. *c.* Conical protrusion of the coat of the commencing intestine, on which the blastema of the liver is formed. *d.* The rudimentary liver. *e.* Portion of the mucous layer of the germinal membrane.

Fig. 472. Under surface of the fœtal liver, with its great blood-vessels, at the full period. The rounded outline of the organ, and the comparatively small difference of size between its two lobes, are seen. *a.* The umbilical vein, lying in the umbilical fissure, and turning to the right side at the transverse fissure (*o*), to join the vena portæ (*p*): the branch marked *d*, named the ductus venosus, continues straight on to join the vena cava inferior (*c*). A few branches of the umbilical vein enter the substance of the liver at once. *g.* The gall-bladder. (After an enlarged model.)

Up to the moment of birth most of the blood returned from the placenta by the umbilical vein passes through the liver of the fœtus before it reaches the heart. At this period the umbilical vein runs from the umbilicus along the free margin of the suspensory ligament towards the anterior border and under surface of the liver, beneath which it is lodged (fig. 472,[a]) in the umbilical fissure, and proceeds as far as the transverse fissure. Here it divides into *two* branches: one of these ([d]), the smaller of the two, continues onwards in the same direction, and joins the vena cava ([c]); this is the *ductus venosus*, which occupies the posterior part of the longitudinal fissure, and gives to it the name of the fossa of the ductus venosus. The other and larger branch (the trunk of the umbilical vein) turns to the right along the transverse or portal fissure ([o]), and ends in the vena portæ ([p]), which in the fœtus is of comparatively small dimensions. Moreover, the umbilical vein, as it lies in the umbilical fissure, and before it joins the vena portæ, gives off some lateral branches, which enter the left lobe of the liver. It also sends a few branches to the square lobe and to the lobe of Spigelius.

The blood of the umbilical vein therefore reaches the ascending vena cava in three different ways. Some passes directly into it by the ductus venosus; another, and the principal portion, passes first through the portal veins, and then through the hepatic veins; whilst a third portion enters the liver directly, and is also returned to the cava by the hepatic veins.

Changes after birth.—Immediately after birth, at the cessation of the current hitherto passing through the umbilical vein, and at the commencement of an increased circulation through the lungs, the supply of blood to the liver is diminished perhaps two-thirds. The umbilical vein and ductus venosus become empty and contracted, and, soon after, they begin to be obliterated, and are ultimately converted into the fibrous cords already described—that one which represents the umbilical vein, constituting the round ligament of the liver. At the end of six days the ductus venosus has been found to be closed; but it sometimes continues open for several weeks.

Concurrently with, and doubtless in some measure dependent on, the sudden diminution in the quantity of blood supplied to the liver after birth, this organ appears at first to become absolutely lighter; and, according to some data, this decrease of weight is not recovered from until the conclusion of the first year. After that period, the liver, though it increases in size, grows more slowly than

the body, so that its relative weight in regard to the body, which was 1 to 18 just before birth, becomes gradually less and less. At about five or six years of age it has reached the proportion maintained during the rest of life, viz., 1 to 36.

The relative weight of the left lobe to that of the right (which, as above stated, is about 1 to 1·6 immediately before birth) undergoes a diminution afterwards. Thus, at a month old, it has been found to be as 1 to 3, and in after life the proportion is generally 1 to 4 or 5.

Varieties.—The liver is not subject to great or frequent deviation from its ordinary characters. Sometimes it retains the thick rounded form which it presents in the fœtus; and it has occasionally been found without any division into lobes. On the contrary, Sœmmerring has recorded a case in which the adult liver was divided into twelve lobes; and similar cases of multiple liver (resembling that of some animals) have been now and then observed by others. A detached portion, forming a sort of *accessory* liver, is occasionally found appended to the left extremity of the gland by a fold of peritoneum containing blood-vessels.

THE PANCREAS.

The *pancreas* (fig. 473, *h*, *t*: *πας κρεας*, *all flesh*) is a long, narrow, flattened gland, larger at one end than the other, which lies deeply in the cavity of the abdomen, immediately behind the stomach, and op-

Fig. 473.

In this figure, which is altered from Tiedemann, the liver and stomach are turned up, to show the duodenum, the pancreas, and the spleen. *l*. The under surface of the liver. *g*. Gall-bladder. *f*. The common bile-duct, formed by the union of a duct from the gall-bladder, called the cystic duct, and of the hepatic duct coming from the liver. *o*. The cardiac end of the stomach, where the œsophagus enters. *s*. Under surface of the stomach. *p*. Pyloric end of stomach. *d*. Duodenum. *h*. Head of pancreas; *t*, tail; and *i*, body of that gland. The substance of the pancreas is removed in front, to show the pancreatic duct (*e*) and its branches. *r*. The spleen. *v*. The hilus, at which the blood-vessels enter. *c*. Crura of diaphragm. *n*. Superior mesenteric artery. *a*. Aorta.

posite the first lumbar vertebra. Its larger end, which is turned to the right, is embraced by the curvature of the duodenum, whilst its left or narrow extremity reaches to a somewhat higher level, and is in contact with the spleen. It extends, therefore, across the epigastric into both hypochondriac regions.

In its general form the pancreas bears some resemblance to a hammer, or, what is a better comparison, to a dog's tongue. Its broad end is named the *head* (*h*), the narrow extremity the *tail* (*t*), and the intermediate portion, which is compressed in front and behind, the *body* of the gland (*i*).

The right or large end of the pancreas is bent from above downwards, and accurately fills the curvature of the duodenum. The lower extremity of this curved portion passes to the left, behind the superior mesenteric vessels, forming the posterior wall of the canal in which they are enclosed. This part of the gland is sometimes marked off from the rest, and is then named the *lesser pancreas*.

The pancreas varies considerably, in different cases, in its size and weight. It is usually from 6 to 8 inches long, about 1½ inch in average breadth, and from half an inch to an inch in thickness, being thicker at its head and along its upper border than elsewhere. The weight of the gland, according to Krause and Clendinning, is usually from 2¼ oz. to 3½ oz.; but Meckel has noted it as high as 6 oz., and Sœmmerring as low as 1½ oz.

The principal attachment of the pancreas is to the duodenum (*d*), with which it is connected by numerous blood-vessels and cellular tissue, but more particularly by its own excretory duct or ducts. It is also retained in its position by its connexion with several large blood-vessels, and by a layer of the peritoneum. Thus, its anterior surface, concealed by the lower border of the stomach, which moves freely over the gland, is covered by that part of the peritoneum which forms the ascending layer of the transverse mesocolon, along the root of which the gland may be said to lie. Behind, the pancreas is attached by cellular tissue to the vena cava, the aorta, the superior mesenteric artery (*n*) and vein, the commencement of the vena portæ, and the pillars of the diaphragm, all of which parts, besides many lymphatic vessels and glands, are interposed between it and the upper lumbar vertebra. To the left of the vertebral column, the pancreas is attached behind in a similar way to the left supra-renal capsule and kidney and to the renal vessels. Of the large vessels situated behind the pancreas, the superior mesenteric artery and vein are embraced by the substance of the gland, so as sometimes to be enclosed in a complete canal, through which they pass downwards and forwards, and then appear beneath the lower border of the pancreas, between it and the termination of the duodenum. The cœliac axis is above the pancreas; and lying in a groove along the upper border of the gland are found the splenic artery and vein, the vein pursuing a straight, and the artery a tortuous course (figs. 247, 263). Both of these vessels supply numerous branches to the body and tail of the pancreas, the narrow extremity of which is thus suspended or attached to the inner border of the spleen. The head of the pancreas, embraced by the inner curved border of the duodenum, is attached more particularly to the descending and transverse portions of that intestine, beyond which it projects somewhat both in front and behind. The ductus communis choledochus passes down behind the head of the pancreas, and is generally received into a sort of groove or canal in its substance.

Structure.—The pancreas belongs to the class of compound conglomerate glands. In its general characters, and also in its intimate structure, it closely resembles the salivary glands, but it is somewhat looser and softer in its texture. It consists of numerous lobes and lobules, of various sizes, held together by cellular tissue, blood-vessels,

and ducts. The cellular tissue penetrates between the larger and smaller lobules, and connects them more or less firmly together into groups and into a whole; it also serves to attach the entire gland to adjacent parts, but it forms no consistent investment or capsule around it. The lobules, aggregated into masses, are rounded or slightly flattened at the sides, so as to be moulded or adjusted compactly to each other; their substance is of a reddish cream-colour, and the arrangement of the commencing ducts and vessels is similar to that in the lobules of the parotid gland, which has been already described (p. 438).

The principal excretory duct, called the *pancreatic duct* (fig. 473, *e*), or the *canal of Wirsung*, (by whom it was discovered in the human subject in 1642,) runs through the entire length of the gland, from left to right, buried completely in its substance, and placed rather nearer its lower than its upper border. Commencing by the union of the small ducts derived from the groups of lobules composing the tail of the pancreas, and receiving in succession at various angles, and from all sides, the ducts from the body of the gland, the canal of Wirsung increases in size as it advances towards the head of the pancreas, where, amongst other large branches, it is usually joined by one derived from that portion of the gland called the lesser pancreas. Curving slightly downwards, the pancreatic duct then comes into contact with the left side of the ductus communis choledochus, which it accompanies to the back part of the descending portion of the duodenum. Here the two ducts, placed side by side, pass very obliquely through the muscular and cellular coats of the intestine, and terminate, as already described, (p. 490,) on its internal mucous surface, by a common orifice, situated at the junction of the descending and horizontal portions of the duodenum, between three and four inches below the pylorus. It sometimes occurs that the pancreatic duct and the common bile-duct open separately into the duodenum. The pancreatic duct, with its branches, is readily distinguished from the glandular substance, from the very white appearance of its thin fibrous walls. Its widest part, near the duodenum, is from 1 line to 1½ line in diameter, or nearly the size of an ordinary quill; but it may be easily distended beyond that size. It is lined by a remarkably thin and smooth mucous membrane, which near the termination of the duct occasionally presents a few scattered follicles.

Sometimes the pancreatic duct is double up to its point of entrance into the duodenum; and a still further deviation from the ordinary condition is not unfrequently observed, in which there is a *supplementary* duct, derived from the lesser pancreas or some part of the head of the gland, opening into the duodenum by a distinct orifice, at a distance of even one inch or more from the termination of the principal duct. Like the salivary glands, the pancreas receives its blood-vessels at all points. Its arteries are derived chiefly from the pancreatico-duodenal branch of the hepatic artery, and from the splenic artery; but it also receives branches from the root of the superior mesenteric. Its blood is returned by the splenic and superior mesenteric veins. Its lympha-

tics terminate in the lumbar vessels and glands. The nerves of the pancreas are derived from the solar plexus.

Development.—In its origin and development, the pancreas altogether resembles the salivary glands. It appears a little earlier than these glands, in the form of a small bud from the left side of the intestinal tube, close to the commencing spleen.

Secretion.—The fluid secreted by the pancreas, called the *pancreatic juice*, flows into the duodenum through the common orifice of the two ducts, probably accompanied by some bile, and, then being mixed with the chyme, assists in the further changes of the latter. Owing to the striking resemblances in structure between the pancreas and the salivary glands, the former was named by the German anatomists the abdominal salivary gland; but recent analyses have shown some important differences in the constitution of their respective secretions. Like the saliva, the pancreatic juice is a clear colourless fluid, which has diffused in it a few microscopic corpuscles; it presents sometimes an acid and sometimes an alkaline reaction, and it contains mucus, chloride of sodium, phosphate and sulphate of soda, and phosphate and carbonate of lime. It differs from saliva, in having a larger proportion of solid constituents, in containing albumen and caseine, and in being quite free from sulphocyanogen.

THE SPLEEN.

The spleen (fig. 473, *r:* lien, σπλην) is a soft, highly vascular, and easily distensible organ, of a dark bluish or purplish gray colour. It is situated in the left hypochondrium, at the cardiac end of the stomach, between that viscus and the diaphragm, and is protected by the cartilages of the ribs. Though extraordinarily rich in blood-vessels, the spleen has no excretory duct; it is therefore associated by anatomists with the thyroid body and supra-renal capsules, as one of the class of blood-glands or vascular glands.

The shape of the spleen is irregular and somewhat variable: it forms a compressed oval mass, placed nearly vertically in the body, and having two faces, one external, convex and free, which is turned to the left, the other internal and concave, which is directed to the right, and is applied to the cardiac end or great cul-de-sac of the stomach. The borders or circumference resulting from the junction of these two faces may, for the purposes of description, be conveniently considered as forming an anterior and a posterior border, and an upper and lower end.

The external free convex face of the spleen, smooth and covered by the peritoneum, is in contact with the under surface of the left side of the diaphragm, and corresponds with the ninth, tenth, and eleventh ribs. The internal concave face is irregular, and is divided into two unequal portions or surfaces, one anterior and larger, the other posterior and smaller, which meet at a longitudinal or vertical fissure, named the *hilus* or fissure of the spleen (*v*). Along the bottom of this fissure are large openings or depressions, which transmit blood-vessels, with lymphatics and nerves, to and from the interior of the organ. In some cases there is no distinct fissure, but merely a row of openings for the vessels; and in others the situation of the hilus is occupied by a longitudinal ridge, interrupted by the vascular orifices. Two layers of peritoneum, reflected from the spleen, at the borders of the hilus, on to the great cul-de-sac of the stomach, and containing between them the splenic vessels and nerves and the vasa brevia, constitute the

gastro-splenic omentum (ligamentum gastro-lienale), which thus serves to attach the spleen to the cardiac end of the stomach. In front of the gastro-splenic omentum, the concave face of the spleen is smooth, invested with peritoneum, and is closely applied to the stomach; the posterior portion of that face, situated behind the ligament and hilus, is in contact with the left pillar of the diaphragm and the corresponding supra-renal capsule. The tail of the pancreas touches the lower end of the inner surface of the spleen.

The anterior margin of the spleen, which is free, and curved so as to be applied to the stomach, is thin, and often slightly notched, especially towards its lower part. The posterior border and upper end are thick or rounded, and rest against the left kidney and the diaphragm. To the former the spleen adheres by loose cellular tissue; and to the latter it is attached by a reflection of the peritoneum, named the *suspensory ligament* (ligamentum phrenico-lienale). The lower end is pointed, and is in contact with the left end of the arch of the colon, or with the transverse mesocolon.

As the spleen is attached by the gastro-splenic omentum to the stomach, and by the suspensory ligament to the diaphragm, its position in the abdomen is necessarily changed by the movements of those parts. Thus, during expiration and inspiration, it rises and falls with the diaphragm,—not, however, descending below the margins of the ribs, when of its ordinary size.

The spleen varies in magnitude more than any other organ in the body; and this not only in different subjects, but in the same individual, under different conditions—sometimes appearing shrunk, and at others being much distended. On this account it is difficult or impossible to state what are its ordinary weight and dimensions: in the adult it is generally about 5 or 5½ inches from the upper to the lower end, 3 or 4 inches from the anterior to the posterior border, and 1 or 1½ inch from its external to its internal surface; and its usual volume, according to Krause, is from 9¾ to 15 cubic inches. In the greater number of a series of cases examined by Dr. John Reid, its weight ranged from 5 to 7 oz. in the male, and was somewhat less in the female; but even when perfectly free from disease, it may fluctuate between 4 and 10 oz. After the age of forty the average weight gradually diminishes. The specific gravity of this organ, according to Haller, Sœmmerring, and Krause, is about 1·060 to 1·000. In intermittent and in other fevers the spleen is much distended and enlarged, reaching below the ribs, and weighing as much as 18 or 20 lbs. In enlargement and solidification of this organ, it has been known to weigh upwards of 40 lbs.; and it has been found reduced by atrophy to two drachms.

Structure.—The spleen has two membranous investments,—a serous coat derived from the peritoneum, and a special albugineous fibro-elastic tunic. The substance of the organ, which is very soft and easily lacerated, is of a dark reddish brown colour, but acquires a bright red hue on exposure to the air. Sometimes, however, the substance of the spleen is paler, and has a grayish aspect. It also varies in density, being occasionally rather solid though friable. The sub-

stance of the organ consists of a reticular framework of white elastic bands, of an immense proportion of blood-vessels, the larger of which run in elastic canals, and of a peculiar intervening pulpy substance, besides lymphatic vessels and nerves. As previously mentioned, it has no system of ducts.

The *external* serous or peritoneal coat is thin, smooth, and firmly adherent to the elastic tunic beneath, but it may be detached by careful dissection, commencing at the borders of the hilus. It forms only a partial covering for the spleen, for though it closely invests the free surface of this organ, it is wanting opposite the hilus and at the posterior border, where the peritoneum is reflected from the spleen on to the stomach and diaphragm.

The *internal*, elastic, or proper tunic is much thicker and stronger than the serous coat, unlike which it covers the entire surface of the organ. It is whitish in colour, and is composed of interlaced bundles of cellular tissue mixed with a fine elastic tissue. In addition to these there are found, especially in the bullock's spleen, pale soft fibres, apparently plain or unstriped muscular fibres, resembling those of the middle coat of arteries.* This elastic tunic cannot be raised from the spleen, because numerous bands or prolongations pass from its internal surface into the substance of the organ. Along the hilus this coat is reflected into the interior of the spleen, in the form of elastic sheaths or canals, which surround or include the large blood-vessels and nerves, and their principal branches. Stretching across in all directions between these sheaths, and traversing the intermediate substance of the spleen, are multitudes of small elastic bands, named *trabeculæ* (diminutive of *trabs*, a beam): many of these bands, moreover, are attached to the internal surface of the proper tunic of the spleen, which they exactly resemble in structure, and of which they form the inward prolongations just spoken of. The proper coat, the sheaths of the vessels, and the trabeculæ being all of a highly elastic nature, constitute a distensible framework, which contains in its interstices or areolæ the vessels and the red pulpy substance of the spleen. It is owing to this structure, endowed perhaps with vital contractility as well as mere elasticity, that the organ is capable of such great

* The statement in the text is founded on what I had observed more than two years ago, and have since been in the habit of mentioning in my lectures. The observation, however, was not followed up. Since the above was in type, I have received from Professor Kölliker a paper (from the "Mittheilungen der Zürcher naturforschenden Gesellchaft," for June, 1847) containing the results of investigations made by him into the structure of the spleen in many different animals, from which, without being aware of my observation, he arrives at the conclusion that the spleen is a "muscular organ." The muscular fibres are of the plain variety, and mixed with elastic or nuclear fibres. In some animals, as the pig, dog, and cat, they exist in the allugineous or proper coat, the sheaths of the vessels and the trabeculæ; in the rabbit they are wanting in the coat, and in the ox, according to Kölliker, they are found only in the small-sized and microscopic trabeculæ, the rest of the trabecular structure and proper coat consisting merely of elastic and cellular tissue. He finds that the muscular tissue of the spleen is, for the most part, made up of short, flat, pale fibres, from $\frac{1}{600}$ to $\frac{1}{240}$ inch long, bearing oblong nuclei. As to the human spleen, he could discover muscular structure neither in the proper coat, nor in the larger trabeculæ; but the fine microscopic trabeculæ appeared to be made up of elongated cells, with round nuclei, which he is disposed to regard as elements constituting a muscular tissue. He could obtain no unequivocal evidence of contraction on irritating the spleen in recently killed animals.—W. S.

and sudden alterations of size. The arrangement of the elastic sheaths and trabeculæ may be easily displayed by pressing and washing out the intervening substance.

The splenic artery and vein, alike remarkable for their great proportionate size, having entered the spleen by six or more branches, ramify in its interior, enclosed within the elastic sheaths already described. The smaller branches of the arteries run along the trabeculæ, and terminate in the proper substance of the spleen in small tufts or pencils of capillary vessels. The veins, which greatly exceed the arteries in size, anastomose frequently together, so as to form a close venous plexus, placed in the intervals between the trabeculæ, and supported by them. It is stated by Krause that the veins form numerous lateral dilatations or diverticula, which communicate with the general plexus, and the walls of which are formed principally by the lining membrane of the veins. Each large vein also receives in its course many small branches, the orifices of which give a dotted appearance to the interior of the vein. From the facility with which fluid injections pass from the arteries into the veins, the communication between the two sets of vessels must be very free; but the mode in which it takes place is not yet determined.

The *proper substance* of the spleen is a soft pulpy mass, of a dark reddish brown colour, which, when squeezed out from between the trabeculæ, resembles grumous blood, and, like that fluid, acquires a brighter hue on exposure to the air. This pulpy substance lies altogether outside the veins, between the branches of the venous plexus. As shown by the microscope, it consists chiefly of numerous rounded granular bodies, which have a reddish colour, and are about the size of the blood corpuscles. Their cohesion is very slight, and the terminal tufts of the arterial system of vessels spread out amongst them. In examining the substance of the spleen, elongated caudate corpuscles are seen in rather large numbers.

On closely inspecting the surface of a section of the spleen, a number of white spots of variable size are always seen. For the most part these are evidently the ends of divided trabeculæ or blood-vessels; but in the ox, pig, sheep, and some other animals, and also, too, in the human subject, there are found distinct white vesicular bodies attached to the trabeculæ, which support the small arteries, and embedded in groups of six or eight together in the dark red substance of the spleen. These little vesicles or capsules, formerly known as the Malpighian *corpuscles of the spleen*, were discovered in the pig by Malpighi, who thought they were situated within the veins. They are rounded capsules, varying in diameter from $\frac{1}{25}$th to $\frac{1}{60}$th of an inch, and consisting of two coats, the external apparently continuous with the trabecular tissue supporting the arteries. They are filled with a soft, white, semi-fluid matter, which contains microscopic globules, resembling, except in colour, those composing the red pulp of the spleen. It may be remarked, that both these kinds of globules are very like the chyle corpuscles.

These capsules are attached in groups to the smaller vascular sheaths or trabeculæ, by the minute branches of a small artery, which

is itself supported by the elastic sheath or band. In some of the lower animals they are sessile, but in the human spleen they are pedunculated. The arterial capillaries do not penetrate them, but appear to form around them a sort of vascular coat or envelope. It has been conjectured by some that these vesicular bodies are dilatations of the lymphatics of the spleen, but their true nature and connexions are not yet ascertained.

The lymphatic vessels of the spleen are very abundant, and form a superficial and deep set. The superficial set appear as a network beneath the serous coat, receive occasional branches from the substance of the spleen, and run towards the hilus. The deep lymphatics accompany the blood-vessels, and emerge with them at the hilus, whence, communicating with the superficial set, they proceed along the gastro-splenic omentum to the neighbouring lymphatic glands. The mode in which the lymphatics commence in the spleen is unknown.

The splenic nerves derived from the solar plexus surround and accompany the splenic artery and its branches. They have been traced by Remak deeply into the interior of the organ.

Development.—The spleen appears in the fœtus, about the seventh or eighth week, on the left side of the dilated part of the alimentary tube, or stomach, and close to the rudiment of the pancreas. By the tenth week it forms a distinct lobulated body placed at the great end of the stomach. After birth it increases rapidly in size; and in comparison with the weight of the body, it is as heavy a few weeks after birth as in the adult. This organ is peculiar to vertebrate animals.

Small detached roundish nodules are occasionally found in the neighbourhood of the spleen, similar to it in substance. These are commonly named *accessory* or *supplementary* spleens (splenculi; lienculi). One or two is the most common number, but four, seven, and even twenty-three have been met with in one subject. They are small rounded masses, varying from the size of a pea to that of a walnut. They are usually situated near the lower end of the spleen, either in the gastro-splenic omentum, or in the great omentum. These separate splenculi in the human subject bring to mind the multiple condition of the spleen in some animals, and also the notching, often deep, of the anterior margin of this organ in man.

Uses.—The function of the spleen is unknown. Besides any mechanical office it may perform, as a diverticulum for the blood, it is thought by many to be concerned in the formation of that fluid. It has been imagined to be an appendage of the lymphatic system; and it has also been supposed to assist in preparing blood for the secretion of the bile. But it would be useless to recount all the various hypotheses which have been at different times entertained respecting its offices.*

THE PERITONEUM.

The common cavity of the abdomen and pelvis is lined by a serous

* Kölliker is led to infer from his observations that the blood corpuscles suffer destruction, or at least decomposition, in the spleen. He supposes that they decrease in size, group together in round clumps, which acquire nuclei and envelopes, so as to constitute cells filled with altered blood corpuscles; that the substance of the contained blood corpuscles is then resolved into pigment granules, of a golden yellow, brown or black colour, and that the cells may thus remain or become blanched into colourless cells very much resembling the pale corpuscles of the blood. He is uncertain how they are finally disposed of.—(See his paper already quoted.)

membrane, named the *peritoneum* (περιτεινω), which is reflected over the contained viscera. It is the most extensive and complicated of all the serous membranes, and like them it forms a shut sac, on the outside of which are placed the viscera which it covers. In the female, however, it is not completely closed, for the two Fallopian tubes at their free extremity open into the cavity of the peritoneum. The internal surface of the peritoneal membrane is free, smooth, and moist, and is covered by a thin squamous epithelium (fig. 274, p. 60). Its external or attached surface adheres partly to the inner walls of the abdomen and pelvis, and partly to the outer surface of the viscera situated within them. The former part, named the *parietal* portion, is connected loosely with the fasciæ lining the abdomen and pelvis, but more firmly along the middle line of the body in front, as well as to the under surface of the diaphragm. This connexion takes place by means of a cellular layer, distinct from the abdominal fasciæ, and named the *sub-peritoneal* or *retro-peritoneal* membrane. The *visceral* portion, which is thinner than the other, forms a more or less perfect investment to the abdominal and pelvic viscera. Some of these organs, as the liver, spleen, stomach, and small intestine, (except the duodenum,) the transverse colon, sigmoid flexure, upper end of the rectum, and the uterus and ovaries, are almost entirely surrounded by peritoneum. Others receive only a partial covering from it, as the two lower portions of the duodenum, the cæcum, the ascending and descending colon, the middle portion of the rectum, and the upper part of the vagina and bladder. Over a few parts, the peritoneum passes without forming any distinct coat for them, as the pancreas, supra-renal capsules, and kidneys. Lastly, the lower end of the rectum, the base and neck of the bladder, the prostate in the male and the lower part of the vagina in the female, have no peritoneal investment.

Folds.—Besides covering the viscera, the peritoneum forms numerous duplicatures, which not only serve as means of attachment and support to the various organs, but also enclose the vessels and nerves of each part, as they pass to and from the back part of the abdomen. Some of these folds, constituting the *mesenteries*, connect certain portions of the intestinal canal with the posterior wall of the abdomen: they are, the mesentery properly so called for the jejunum and ileum, the meso-cæcum, transverse and sigmoid meso-colon, and the meso-rectum. Other duplicatures, which are called *omenta*, proceed from one viscus to another: they are distinguished as the great omentum, the small omentum, and the gastro-splenic omentum. Lastly, certain reflections of the peritoneum from the walls of the abdomen or pelvis to viscera which are not portions of the intestinal canal, are named *ligaments:* these include the ligaments of the liver, spleen, uterus, and bladder, and are elsewhere described with the organs to which they are respectively attached.

Omenta.—The *great omentum*, *gastro-colic omentum*, or *great epiploon* (επιπλεω; fig. 246, 7), is a broad process of peritoneum which depends from the lower border of the stomach and the transverse

colon, and below that point lies free, in front of the convolutions of the small intestine, reaching nearly as low down as the pelvis. On the left the great epiploon is continuous with the gastro-splenic omentum: to the right it reaches only to the duodenum. At its upper border, which is concave, and attached to the great curvature of the stomach, it consists of two coherent layers of serous membrane, descending, one from the front, the other from the back of the stomach (fig. 474, *s*). These two layers (^{6}) applied one to the other, descend to the lower convex limit of the omentum, which hangs freely in the abdomen, and there turning upwards, ascend to be attached along the transverse colon (c), becoming continuous with its peritoneal coat; hence the name, gastro-colic omentum. In its lower free portion, that is, below the colon, it therefore comprehends in its thickness four layers of peritoneum, two ascending and two descending. This may be demonstrated in young subjects: in the adult the two double layers become inseparably united. The compound structure thus formed is very thin, and is sometimes perforated with holes like lace. It always contains some adipose tissue, and in fat subjects it is much loaded. Large vessels descending from the gastro-epiploic arteries supply it with blood.

The *small* or *gastro-hepatic omentum*, the *small epiploon*, is a duplicature of the peritoneum,[4] which extends from the lesser curvature of the stomach to the transverse fissure and to the fossa of the ductus venosus, on the under surface of the liver, and encloses the hepatic vessels and ducts. At the left border of this omentum its two layers pass on to the end of the œsophagus; but at the right border they become continuous with each other, so as to form a free rounded margin, and enclose the vena portæ, the hepatic artery, and the biliary duct. Behind this free margin with its contained vessels, in front of the ascending vena cava, and immediately below the Spigelian lobe of the liver, is an opening or short canal, named the *foramen of Winslow.* This canal leads down behind the stomach into a space named the *sac of the omentum.* This space, which may be shown by holding the parts asunder, is therefore placed behind the small omentum and below the liver: it extends downwards between the posterior surface of the stomach and the upper or ascending layer of the transverse mesocolon. In young subjects, by forcing air into the foramen of Winslow, the continuance of this sac is further shown between the two descending and the two ascending lamellæ of the great omentum, down to the lower border of that process of the peritoneum. Its smooth lining membrane is continuous with the rest of the peritoneum at the foramen of Winslow, which is therefore not a perforation in the peritoneum.

The *gastro-splenic omentum* (*or ligament*) is another duplicature, which passes from the cul-de-sac of the stomach to the borders of the hilus of the spleen. It contains the splenic vessels and the vasa brevia. At its right or lower margin it is continuous with the great omentum.

Mesenteries.—The *mesentery* proper is that large and important

duplicature of the peritoneum which is attached by its posterior border to the front of the vertebral column, and is connected along its anterior border with the convolutions of the jejunum and ileum. Its attachment to the vertebral column, named the root of the mesentery, is not more than six inches long, and extends in an oblique line from the left side of the second lumbar vertebra to the right sacro-iliac symphysis. At its upper end this border of the mesentery receives the superior mesenteric vessels, and is continuous with the under surface of the transverse meso-colon; at the lower end it gradually spreads into the peritoneum of the ascending colon. The anterior border of the mesentery, to which the intestine is attached, is of much greater length.

At its widest part the mesentery is about four inches from its vertebral to its intestinal border. Between the two layers of serous membrane of which it consists are placed, besides some fat, numerous branches of the superior mesenteric artery and vein, together with nerves, lacteal vessels, and the mesenteric glands (see p. 44). In front, the two layers open out, as it were, to embrace the intestinal tube, and become continuous along its free border, thus forming its peritoneal covering.

Meso-cæcum.—In some cases the cæcum is suspended at a short distance from the right iliac fossa, by a distinct duplicature of the peritoneum, which is termed the meso-cæcum; but, more commonly, the peritoneum merely binds down this part of the large intestine, and forms a distinct but small mesentery for the vermiform appendix only.

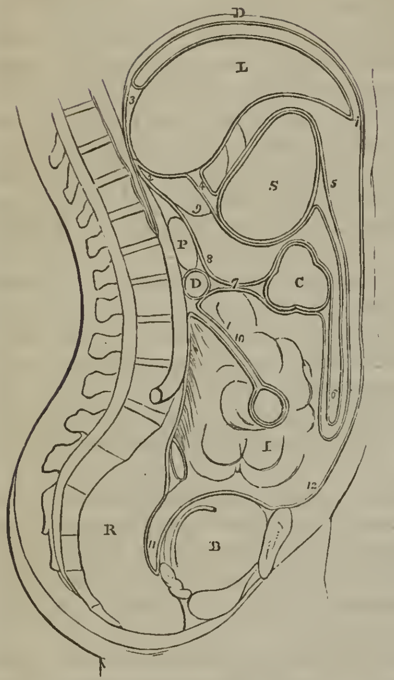
Meso-colon.—The ascending and descending portions of the colon are bound down by the peritoneum, which usually passes only over the front and sides of the intestine, but sometimes forms a narrow duplicature behind them, named ascending or descending meso-colon. The transverse part of the colon, however, is always supported by a very broad duplicature, named the *transverse meso-colon.* This is, in fact, formed by the continuation backwards of the two ascending layers of the great omentum, which, after reaching the front of the transverse colon, separate so as to enclose that intestine, and, meeting again behind it, are continued backwards (as the transverse meso-colon) to the spine. Here its two layers diverge, one continuing upwards over the pancreas, and the other downwards over the transverse portion of the duodenum, both these organs thus obtaining a partial peritoneal covering. The peritoneum forms rather a broad duplicature behind the freely suspended sigmoid flexure of the colon.

The *Meso-rectum* is a narrow duplicature which connects the upper part of the rectum with the sacrum.

The way in which the peritoneum is reflected from the walls of the abdomen and from one organ to another, and the mode in which its numerous duplicatures are formed, may now be traced consecutively. Commencing at the small omentum (fig. 474, [4]) as a starting-point, that structure will be found to consist of two layers of the serous membrane. Of these we shall first follow the upper or anterior, and then the lower or posterior layer. 1. The *upper* layer may be traced to the small curvature of the stomach (s), and then over the anterior surface

of that organ as far as the great curvature; from this it reaches down, forming the *outermost* layer of the great omentum ([5]), at the lower border of which it becomes reflected upwards, and ascends to the transverse colon (C); having invested the under surface of this part of the large intestine, it passes backwards, forming the under layer of the transverse meso-colon ([7]), and reaches the back of the abdominal cavity beneath the transverse part of the duodenum (D). Below this point it is continued on either side to the right and left colon, and thus on to the anterior wall of the abdomen, whilst in the middle it is prolonged forwards from the spine to the small intestine (I), after investing which, it returns to the front of the spine, and thus completes the mesentery ([10]), which, as elsewhere mentioned, consists of two contiguous layers. From the root of the mesentery it descends in front of the spine, and partially invests the rectum (R), the uterus, and the bladder (B), forming folds at the points of reflection from one organ to another, as is elsewhere more particularly described. From the summit of the bladder it is prolonged to the anterior wall of the abdomen ([12]), and then continues to ascend as high as the costal cartilages, where it comes into contact with the diaphragm (D), and lines the under surface of that muscle. From the diaphragm, the layer of peritoneum we are now tracing is reflected upon the liver at [3], forming its lateral and the upper layer of its coronary ligaments; it reaches the liver, too, as the suspensory or broad ligament, a nearly median duplicature passing off from the right rectus muscle and diaphragm; it next invests the upper and then the under surface of the liver (L), as far as the transverse fissure, where it is reflected down upon the hepatic vessels, forming the upper or anterior layer of the small omentum ([4]), from which we began to trace its reflections. 2. The *under* or posterior layer of the small omentum may be traced to the small curvature of the stomach, and thence along the posterior surface of this organ as far as its great curvature; from this point the membrane reaches down, forming the innermost layer of the great omentum ([6]), at the lower border of which it is reflected up to the transverse colon (C); after investing the upper surface of this part of the large intestine, it is reflected back towards the spine, forming the upper layer of the transverse meso-colon ([8]); it

[Fig. 474.



The reflections of the peritoneum. D. The diaphragm. S. The stomach. C. The transverse colon. D. The transverse duodenum. P. The pancreas. I. The small intestines. R. The rectum. B. The urinary bladder. 1. The anterior layer of the peritoneum, lining the under surface of the diaphragm. 2. The posterior layer. 3. The coronary ligament, formed by the passage of these two layers to the posterior border of the liver. 4. The lesser omentum; the two layers passing from the under surface of the liver to the lesser curve of the stomach. 5. The two layers meeting at the greater curve, then passing downwards and returning upon themselves, forming (6) the greater omentum. 7. The transverse meso-colon. 8. The posterior layer traced upwards in front of D, the transverse duodenum, and P, the pancreas, to become continuous with the posterior layer (2). 9. The foramen of Winslow; the dotted line bounding this foramen inferiorly marks the course of the hepatic artery forwards, to enter between the layers of the lesser omentum. 10. The mesentery encircling the small intestine. 11. The recto-vesical fold, formed by the descending anterior layer. 12. The anterior layer traced upwards upon the internal surface of the abdominal parietes to the layer (1), with which the examination commenced.—W.]

is thence prolonged in front of the pancreas (P) and the crura of the diaphragm: from the under surface of the diaphragm it is reflected on to the liver at [2], and helps to form the under layer of its coronary ligament: having invested the under surface of the liver as far as the transverse fissure, it is there reflected downwards, and forms the under or posterior layer of the small omentum ([4]), from which we commenced the description, and the right border of which, being free, forms the anterior margin of the foramen of Winslow. In ascending along the back of the abdominal cavity to the liver, this posterior layer passes to the right over the vena cava, and there bounds the foramen of Winslow behind, and still further to the right becomes continuous with the general peritoneal membrane.

The peritoneum may, of course, also be traced continuously from any other point of its surface.

Vessels and nerves.—The vessels and nerves of the peritoneum are derived from many sources. Its internal surface is moistened with a thin fluid. It serves to attach or suspend the viscera, to support their vessels and nerves, and, where that is required, to facilitate their movements on each other.

PARTS SITUATED IN EACH REGION OF THE ABDOMEN.

Subjoined is an enumeration of the organs situated in the different regions of the abdomen.

Epigastric region	The middle part of the stomach, with its pyloric extremity, the left lobe of the liver, the hepatic vessels, and lobulus Spigelii, the pancreas, the cœliac axis, the semilunar ganglia, part of the vena cava, also of the aorta, vena azygos and thoracic duct, as they lie between the crura of the diaphragm.
Hypochondriac, right	The right lobe of the liver with the gall-bladder, part of the duodenum, the hepatic flexure of the colon, the right suprarenal capsule, and part of the corresponding kidney.
Hypochondriac, left	The large end of the stomach with the spleen and narrow extremity of the pancreas, the splenic flexure of the colon, the left suprarenal capsule, and upper part of the left kidney. Sometimes also a part of the left lobe of the liver.
Umbilical	Part of the omentum and mesentery, the transverse part of the colon, transverse part of the duodenum, with some convolutions of the jejunum and ileum.
Lumbar, right	Ascending colon, lower half of the kidney, and part of the jejunum.
Lumbar, left	Corresponding parts at the opposite side.
Hypogastric	The convolutions of the ileum, the bladder in children, and, if distended, in adults also; the uterus when in the gravid state.
Iliac, right	The cæcum, ileo-cæcal valve, the ureter, and spermatic vessels.
Iliac, left	Sigmoid flexure of the colon, the ureter, and spermatic vessels.

THE URINARY ORGANS.

The urinary organs consist of the *kidneys*, by which the urine is secreted, and of the *ureters*, *bladder*, and *urethra*, which are concerned in its excretion and evacuation. As locally connected, the *supra-renal* capsules are usually described with these organs, though they have no relation, as far as is known, to the secretion of urine.

THE KIDNEYS.

The *kidneys* (renes, νεφροι), two in number, one right and the other left, are deeply seated in the lumbar region, lying one on each side of the vertebral column, at the back part of the abdominal cavity, behind the peritoneum. They are situated on a level with the last dorsal and the two or three upper lumbar vertebræ, the right kidney however being placed a little lower down than the left, probably in consequence of the vicinity of the large right lobe of the liver. They are maintained in this position by their vessels, and also by a quantity of surrounding loose cellular tissue, which usually contains much dense fat. The *size* of the kidneys varies in different cases. Ordinarily, they measure about four inches in length, two inches in breadth, and an inch or rather more in thickness. The left kidney is usually longer and thinner, whilst the right is shorter and wider in proportion.

Weight.—The average weight of the kidney is usually stated to be about 4½ ozs. in the male, and somewhat less in the female. According to Dr. Clendinning,* the two kidneys of the male weigh on an average 9⅕ ozs., and those of the female 9 ozs. The estimate of M. Rayer† is 4⅓ ozs. for each organ in the male, and 3⅔ ozs. in the other sex. Dr. J. Reid's‡ observations (made on sixty-five males and twenty-eight females, between the ages of twenty-five and fifty-five) would indicate a higher *average* weight, viz., rather more than 5½ ozs. in the former, and not quite 5 ozs. in the latter,—the difference between the two sexes being therefore upwards of half an ounce. The *prevalent* weights of the kidney, as deduced from the tables of Dr. Reid, are, in the adult male (160 observations) from 4½ ozs. to 6 ozs., and in the adult female (74 observations) from 4 ozs. to 5½ ozs. The tables more recently published by Dr. Peacock give still higher average results as to the weight of these organs.§ The two kidneys are seldom of equal weight, the left being almost always heavier than the right. The difference, according to M. Rayer, is equal to about one-sixth of an ounce. The actual average difference was found by Dr. Reid, in ninety-three cases (male and female), to be rather more than one-fourth of an ounce. The *proportionate* weight of the two kidneys to the *body* is about 1 to 240. The specific gravity of the renal substance is, on an average, 1·052.

The surface of the kidney is smooth and has a deep red colour. Its *form* is peculiar: it is compressed before and behind, convex on its outer and concave on its inner border, and somewhat enlarged at its upper and lower ends.

* Loc. cit. † Traité des Mal. des Reins. Paris, 1839. ‡ Loc. cit. § Loc. cit.

The *anterior* surface, more convex than the posterior, is directed somewhat outwards, and is partially covered at its upper end by the peritoneum, which is separated from it lower down by loose cellular tissue. The duodenum and ascending colon, both destitute of peritoneum behind, are in contact with the anterior surface of the right kidney, and the descending colon with that of the left. The front of the right kidney, moreover, touches the under surface of the liver, and that of the left the lower extremity of the spleen. The *posterior* surface, flatter than the anterior, and embedded in cellular tissue, rests partly upon the corresponding pillar of the diaphragm, in front of the eleventh and twelfth ribs, partly on the quadratus lumborum muscle, or rather on the anterior layer of the lumbar fascia, which covers it, and lastly, on the psoas muscle. The *external border*, convex in its general outline, is directed outwards and backwards towards the walls of the abdomen. The *internal border*, concave and deeply excavated towards the middle, is directed a little downwards and forwards. It presents in its middle a longitudinal *fissure* bounded by an anterior and posterior lip, and named the *hilus of the kidney*, at which the vessels, the excretory duct, and the nerves enter or pass out. In this hilus, the renal vein lies in front, the artery and its branches next, and the expanded excretory duct or ureter behind and towards the lower part of the hilus. The *upper end* of the kidney, which is larger than the lower, is thick and rounded, and supports the supra-renal capsule, which also descends a little way upon its anterior surface. This end of the kidney reaches, on the left side, to about the upper border of the eleventh rib, and on the right half a rib's breadth lower. It is moreover directed slightly inwards, so that the upper ends of the two kidneys are nearer to each other than the lower ends, which are smaller and somewhat flattened, diverge slightly from the spine, and reach nearly as low as the crest of the ilium. It may here be remarked that, by placing the larger end of a kidney upwards and its flatter surface backwards, or by noticing the relation of the parts in the hilus, it may be determined to which side of the body the organ belongs.

Varieties.—The kidneys present varieties in form, position, absolute and relative size, and number. Thus, they are sometimes found longer and narrower, and sometimes shorter and more rounded than usual. Occasionally one kidney is very small, whilst the other is proportionately enlarged. In either of these conditions the position of the kidney, especially as regards its height upon the ribs, must also vary. Independently of any other change, the kidneys may, one or both, be situated low down, even in the pelvis.

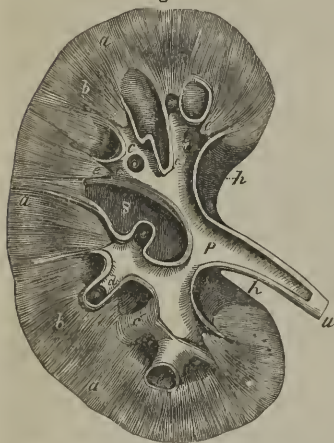
Cases are now and then met with in which but one kidney is present, the single organ being sometimes, though not always, formed by the apparent junction of the two kidneys across the front of the great blood-vessels and vertebral column. The transverse connecting portion usually has its upper border concave, so as to give the organ a form which has suggested the appellation of the *horse-shoe* kidney. Sometimes two united kidneys are situated on one or other side of the vertebral column, in the lumbar region, or, but much more rarely, in the cavity of the pelvis. In other very rare cases, three distinct glandular masses have been found, the supernumerary organ being placed either in front or on one side of the vertebral column, or in the pelvic cavity.

Structure.—Beneath the layer of fatty tissue (tunica adiposa) which

in the adult usually surrounds the kidney, but is accumulated especially upon its outer and inner borders, is the proper fibrous coat of the organ. This coat forms a thin, smooth, but firm investment, immediately and closely covering the whole kidney. It consists of dense fibro-cellular tissue, and can be easily torn off from the substance of the gland, to which it adheres by minute processes and vessels.

On splitting open the kidney by a longitudinal section, from its outer to its inner border (see fig. 475), the fissure named the *hilus* (*h*, *h*), is found to extend some distance into the interior of the organ, forming a cavity within the solid substance of the gland called the *sinus* of the kidney (*s*). The fibrous coat of the kidney, passing in by the hilus, lines the sides of the sinus, and having reached the bottom of that cavity, surrounds the blood-vessels, giving them sheaths which accompany their principal branches in the substance of the gland, and is reflected upon the divisions of the ureter or excretory duct (*c*, *c*, *c*), to be afterwards described. The solid part of the kidney, as is seen on a section, consists of two substances, differing from one another in aspect, and usually named, from their relative position, the cortical and medullary substances. The *external* or *cortical* substance (*a*, *a*, *a*,) is situated immediately beneath the fibrous capsule, and forms the superficial part of the organ throughout its whole extent and to the depth of about two lines. The cortical substance moreover sends prolongations inwards towards the sinus (septula renum), between which the medullary substance is found. The *internal or medullary substance*, on the other hand, does not form a continuous structure, but is collected into a series of conical masses called the *pyramids of Malpighi* (*b*, *b*), the bases of which are directed towards the surface of the kidney, while their apices (*e*, *e*, *e*), are turned towards the sinus. There are generally more than twelve pyramids, but their number is not constant, varying from eight to eighteen. The greater part of each pyramid is embedded in the cortical substance, but the summits of these masses, which project into the sinus, are free, and are named the *papillæ* (or *mamillæ*) of the kidney (*d*, *d*). The cortical portion forms about three-fourths, and the medullary the remaining fourth of the substance of the gland.

Fig. 475.



Plan of a longitudinal section of the kidney and upper part of the ureter, through the hilus, copied from an enlarged model. —*a*, *a*, *a*. The cortical substance. *b*, *b*. Broad part of two of the pyramids of Malpighi. *e*, *e*. Section of the narrow part or apex of two of these pyramids, lying within the divisions of the ureter marked *c*, *c*. *d*, *d*. Summits of the pyramids, called papillæ, projecting into and surrounded by the divisions of the ureter. *c*, *c*. Divisions of the ureter, called the calices or infundibula, laid open. *c'*. A calix or infundibulum unopened. *p*. Enlarged upper end of ureter, named the pelvis of the kidney. *s*. Central cavity or sinus of the kidney.

The *cortical* substance is soft and easily lacerated, the torn surface

presenting a rough irregular aspect, and having a tolerably uniform red colour. It is sometimes said to be darker than the medullary portion, but this is not the fact, for, though the papillæ or summits of the pyramids are often lighter, their bases are usually darker than the surrounding cortical substance. On closely examining a section of a recent kidney, either with or without the aid of a lens, a number of small round dark red points are seen lying in the cortical substance only, but nowhere reaching quite to the surface of the gland. These are the Malpighian bodies or corpuscles of the kidney, to which we shall presently have again to refer. The *medullary* portion of the kidney, which, as already said, forms the pyramids, is more dense than the cortical, and is distinctly striated, owing to its consisting of minute diverging tubes: hence it is often named the *tubular* substance, but the cortical substance is also tubular.

The pyramidal masses found in the adult kidney indicate the original separation of this gland into lobules in the earlier stages of its growth. Each of these primitive lobules is in fact a pyramid, surrounded by a proper investment of cortical substance, and is analogous to one of the lobules of the divided kidneys, seen in many of the lower animals. As the human kidney continues to be developed, the adjacent surfaces of the lobules coalesce and the gland becomes a single mass, and the contiguous parts of the originally separate cortical investments, being blended together, form the partitions between the pyramids already described. Moreover, upon the surface of the kidney even in the adult, after the removal of the fibrous capsule, faintly marked furrows may be traced on the cortical substance, opposite the intervals between the bases of the pyramids, which also indicate the position and course of large veins.

The entire substance of the kidney, whether cortical or medullary, is composed of the uriniferous or excretory ducts, the blood-vessels, lymphatics, and nerves, connected in some parts by a fine cellular tissue, which, however, exists but in very small quantity, together with an intermediate substance, also very scanty, which has been described as a proper parenchyma.

The *ducts.*—The *ureter*, or excretory duct of the gland (*u*), is dilated at its upper end as it approaches the hilus, into a funnel-shaped cavity, compressed before and behind, named the *pelvis* of the kidney (*p*). On entering the sinus, partly concealed by the vessels, the pelvis divides usually into three, or sometimes two, principal tubes, which again subdivide into several smaller tubes named the *calices* or *infundibula* (*c*, *c*, *c*). These calices, which vary in number from seven to thirteen, embrace the prominent portions of the pyramids, forming short funnel-shaped tubes, into which the papillæ (*d*, *d*,) project. Often a single calix surrounds two, sometimes even three papillæ, which are in that case united together; hence, too, the calices are in general not so numerous as the pyramids and papillæ.

Like the rest of the ureter, the calices consist of two coats, viz., a strong external fibro-cellular tunic, which becomes continuous around the bases of the papillæ with that part of the proper coat of the kidney which is continued into the sinus; and, secondly, a thin internal

mucous coat, which is reflected over the summit of each papilla, and is moreover prolonged into a multitude of minute orifices opening on the surface of the papilla, and from which, on pressing the gland, urine may be made to exude. These small orifices vary in diameter from $\frac{1}{300}$th to $\frac{1}{200}$th of an inch; they are frequently collected in large numbers at the bottom of a slight depression or *foveola* found near the summit of the papilla.

Tubuli uriniferi.—On tracing the minute openings just mentioned, into the substance of the pyramids, they are discovered to be the mouths of small tubes or *ducts*, called the *uriniferous tubes* (tubuli uriniferi), which thus open upon the surface of the several papillæ into the interior of the calices.

As these tubuli pass up into the pyramidal substance, they bifurcate again and again at very acute angles, their successive branches running close together in straight and but slightly diverging lines, and continuing thus to divide and subdivide until they reach the sides and bases of the pyramids, from whence they pass, greatly augmented in number, into the cortical substance. Here, however, they undergo a complete change in their direction, for whereas, in the pyramids the radiating tubes are quite straight, they in the cortical part become at once convoluted in a most intricate manner, and retain this character through the remainder of their course. The *straight* portions of these tubuli were early recognised, and are sometimes named the *ducts of Bellini*, but the existence of tubes in the cortical substance was for a long time unknown; in this situation the tortuous uriniferous ducts are called the *tubes of Ferrein*. Within the pyramids, towards their base, the straight tubes are described as being collected into fasciculi, the tortuous tubuli given off from which into the cortical substance form little indistinct conical masses, reaching to the surface of the kidney, which presents in consequence a minutely lobulated or granular aspect. These aggregations of the uriniferous tubes in separate fasciculi and masses, appear connected in some degree with the arrangement of the intermediate blood-vessels, especially of the veins. They have been named the *pyramids of Ferrein*; a great number of which are included in each of the pyramids of Malpighi and its corresponding cortical substance.

On a section made across the base of a papilla, Krause has counted the openings of about one hundred of the straight tubes in a square line; and Huschke has enumerated from four to five hundred larger ones with as many of smaller size on the entire section of the base of a single papilla. The uriniferous tubes are largest near their orifices, at a short distance from which, within the papillæ, their diameter varies, according to Huschke, from $\frac{1}{430}$th to $\frac{1}{240}$th of an inch. Further on in the pyramid they become smaller, measuring about $\frac{1}{600}$th of an inch in diameter, and then do not diminish as they continue to bifurcate, but remain nearly of the same uniform average diameter, until they enter the cortical substance, where the convoluted tubuli vary considerably in diameter, and many of them, indeed, (at least when injected,) present great inequalities at intervals along their course, but

they maintain commonly the same average width as the straight tubes, namely $\frac{1}{500}$th of an inch.

The uriniferous tubes form a system of canals apart from the blood-vessels, which latter are ramified on their walls in form of a fine capillary network, and at certain parts have a more curious relation to them, to be presently described. The convolution of the tubes provides for a large extent of secreting surface in a small space. Their parietes are formed of a transparent and homogeneous basement membrane, or membrana propria, lined by a spheroidal epithelium, which usually occupies about two-thirds of the diameter of the tube. (Fig. 476, A, B, C.)

Different statements are made by different observers as to the mode in which the convoluted uriniferous tubes terminate or (tracing them in the reverse direction) commence in the cortical substance. According to the description given by Mr. Bowman, each tubulus begins by a little saccular dilatation, which embraces one of the vascular tufts named the Malpighian bodies,—the uriniferous tubes, in fact, being continued from, or rather forming by their dilated commencement, the capsules by which, as noticed by previous observers, these bodies are surrounded. The tortuous tubuli have also been seen forming loops, either by the junction of adjacent tubes, or, as stated by Mr. Toynbee,* by the reunion of two branches proceeding from the same tube: in either case, new branches may arise from such loops. Other anatomists again hold, that the tubuli also arise by free and simply closed extremities.

Blood-vessels.—The kidneys are highly vascular, and derive their blood from the right and left renal arteries (vol. i. p. 602), which are very large in proportion to the size of the organs they supply. Each renal artery divides into four or five branches, which, passing in at the hilus, between the vein and ureter, may be traced into the sinus of the kidney, where they lie amongst the infundibula, together with which they are usually embedded in a quantity of fat. Penetrating the substance of the organ between the papillæ, the arterial branches enter the cortical substance found in the intervals between the medullary cones, and go on, accompanied by a sheathing of cellular tissue derived from the proper coat and dividing and subdividing, to reach the bases of the pyramids, where they form numerous anastomotic arches. From these arches a multitude of branches are given off, and, after ramifying through the cortical substance, at length end in a system of capillary vessels, which exist through the whole substance of the kidney, and form a network upon the uriniferous tubes. In the medullary portion of the kidney, where the uriniferous tubes are straight, the blood-vessels form oblong meshes parallel with the tubuli. In the cortical substance, the distribution of the small arteries is peculiar, for, before terminating in the common capillary system, they, with probably very few exceptions, enter into the Malpighian bodies, or glomeruli. All the capillaries of the kidney end in venous radicles, which unite to form the renal vein.

* Medico-Chir. Transactions. 1846.

The Malpighian corpuscles.—These small red bodies, or *glomeruli*, discovered by Malpighi (who, however, did not know their intimate structure), lie embedded in the cortical substance, surrounded loosely by little capsules. They are rounded or slightly oblong in shape, and have an ordinary diameter of $\frac{1}{120}$th of an inch, but sometimes only of $\frac{1}{200}$th or $\frac{1}{270}$th of an inch. When oblong, Krause, has found them to measure $\frac{1}{110}$th of an inch in length, and $\frac{1}{150}$th in width.

These glomeruli were described by Ruysch as consisting of a little coiled artery. They are really, however, little vascular tufts formed,

Fig. 476.

Fig. 477.

Fig. 476. Portions of the uriniferous tubes, magnified (Baly). A. Portion from the cortical substance, lined by its epithelium. B. Epithelial cells, more highly magnified (about 700 times). C. Portion of tube from the medullary substance, at one part deprived of its epithelial lining.

Fig. 477. Plan of the renal circulation; copied from Mr. Bowman's paper. *a*. A branch of the renal artery giving off several Malpighian twigs. 1. An afferent twig to the capillary tuft contained in the Malpighian body, *m*; from the Malpighian body the uriniferous tube is seen taking its tortuous course to *t*. 2, 2. Efferent veins; that which proceeds from the Malpighian body is seen to be smaller than the corresponding artery. *p*, *p*. The capillary venous plexus, ramifying upon the uriniferous tube. This plexus receives its blood from the efferent veins, 2, 2, and transmits it to the branch of the renal vein, *v*.

not, as Ruysch supposed, by the convolutions of a single vessel, but by those of two vessels, one afferent (fig. 477,[1]) the other efferent ([2]), which enter and pass out of the glomerulus (m) close to one another. The afferent vessel immediately divides into several branches, which cover the surface of the glomerulus, and end in a finer set of central vessels. From these the efferent vessel arises, and, passing out of the tuft, at length divides into capillaries, which form a plexus around the adjacent tubuli. Mr. Bowman regards the efferent vessel as a vein, and consequently as having an arrangement comparable to that of the portal vein, and supports his view by a reference to the peculiar disposition of the vessels in the kidneys of reptiles. Others look on a Malpighian tuft as merely an example of an artery breaking up into a rete mirabile, and then after being reconstructed, continuing beyond as the efferent vessel. All the small arteries of the kidney, it must be borne in mind, do not form glomeruli before ending in the capillary

network of the gland, for some of them divide at once into capillaries, without entering these tufts.

Relation of the Malpighian bodies to the uriniferous tubes.—It was thought, by Ruysch, that the single convoluted blood-vessel, supposed by him to form the glomerulus, ultimately became continued on as a straight uriniferous tube; but subsequent researches have shown that, though the Malpighian bodies have peculiar relations with the commencing tubuli, there is no continuity between the channels of the blood-vessels and those of the secreting ducts. The true relation of the two was discovered by Mr. Bowman, and is essentially this, that the uriniferous tube (*t*), by becoming enlarged, forms a capsule into which one of the vascular tufts (*m*) projects, so as to be entirely enclosed within it; and that the two vessels, afferent ([1]) and efferent ([2]), which form the tuft, pierce this capsule usually close to each other. Mr. Bowman inferred from his observations that the dilatation was placed at the end or rather commencement of a tube, but it has since been found by Gerlach and others, that it may be formed on one side. Hence it would appear that the capsules in question may be either *lateral* or *terminal;* and for aught that has yet been proved to the contrary, lateral capsules may exist both on tubes which issue from terminal ones, and on tubes which at their commencement are joined with others or form loops.

According to Bowman, the epithelium becomes remarkably thin within the capsule, and, in the frog, is covered with cilia at the neck of the dilated portion. By the same observer, it is further stated, that neither the epithelium nor the basement membrane of the capsule is reflected over the glomerulus, the vessels of which therefore lie, as it were, naked in the capsular cavity. Gerlach, on the other hand, describes the tuft of vessels as covered with a thick layer of nucleated cells, continued from a similar layer lining the capsule.*

Veins.—Small veins, arising by numerous venous radicles from the capillary network of the kidney, are seen near the surface of the gland, arranged so as to leave between them minute spaces, which appear nearly to correspond with the bases of the so-called pyramids of Ferrein. These vessels, which sometimes have a stellate arrangement (*stellulæ*, Verheyen,) end in larger veins, which again unite into arches around the bases of the pyramids of Malpighi. From thence venous trunks proceed, in company with the arteries, through the cortical envelope between the pyramids, to the sinus of the kidney. Joining together, they escape from the hilus, and ultimately form a single vein, which lies in front of the artery, and ends in the inferior vena cava.

A number of vessels, both veins and arteries, enter the proper coat

* Mr. Toynbee, whose views are different from those above given, conceives that the capsule is not a dilated portion of a uriniferous tube, but is an independent investment, continuous neither with the tube nor with the blood-vessels, but expanded over and enveloping the terminations of both. Further, he believes that the blood-vessels passing into and out of the tuft perforate one end of this proper capsule, whilst the uriniferous tube enters at the opposite point, becomes twisted into a coil in contact with the convoluted blood-vessels, and then again emerges from the capsule.

of the kidney from the cortical substance, and some supply also the surrounding cellular or adipose tissue.

Absorbents.—The lymphatics of the kidney are numerous, consisting of a superficial set, and of deep lymphatics which issue from the hilus with the blood-vessels.

Nerves.—The nerves which have been traced into these organs are small. They come immediately from the renal plexus and the lesser splanchnic nerve, and contain filaments derived from both the sympathetic and cerebro-spinal systems.

Intermediate substance.—Bowman has pointed out the existence of a firm granular substance, lying between and uniting the tubes, as well as the vessels, in the medullary part of the kidney; he compares it to a blastema, and states that it is probably composed of cells. Under the name of the *proper parenchyma* of the kidney, Mr. Toynbee has also described a substance, composed of cells, as interposed between and surrounding the tubuli, in the cortical part as well as elsewhere. He further states, that the fine filaments of the nerves within the kidney have appeared to him to be connected with the intertubular or parenchymal cells.*

Development.—The development of the kidneys, and also that of the supra-renal capsules next to be described, will be given with that of the genito-urinary organs generally.

The Urine.—This is a highly complex fluid, containing in solution *animal compounds* characterized by having a large amount of nitrogen in their composition, and derived, it would seem, from the waste of the tissues; *saline substances*, and *adventitious* matters which have been introduced into the blood. The average quantity secreted daily is about 30 fluid ounces. Its specific gravity varies in health from 1·015 to 1·030, but 1·020 is the average standard. It is acid in its reaction, and contains some mucus and epithelium. One thousand parts of ordinary urine contain 933 pts. of water, and 67 of solid matter. Of the latter, 30 pts. consist of *urea*, the characteristic nitrogenous ingredient of urine; 17 pts. consist of extract with salts soluble in alcohol; 15 pts. are fixed salts, and 1 pt. is uric acid.

SUPRA-RENAL CAPSULES.

The *supra-renal capsules*, or supra-renal glands (glandulæ supra-renales; capsulæ supra-renales, seu atrabilariæ; renes succenturiati), are two gland-like bodies, situated one on each side of the vertebral column, and, as their name implies, above the kidneys. Each of them is a flattened, triangular body, somewhat resembling a cocked hat in shape, which surmounts the corresponding kidney. Its *upper* border, convex and thin, is directed inwards and upwards. Its base or concave border, which rests upon the anterior and inner part of the

* Mr. Goodsir (Lond. and Edin. Journ. of Med. Science, May, 1842), and more lately Dr. Johnson (Cyclop. of Anat. vol. iv. p. 239) have described a fibro-cellular framework or matrix as pervading every part of the renal substance, and supporting the uriniferous tubes and blood-vessels. We must confess, that although small bundles of fibrous or cellular tissue are met with here and there accompanying vessels in the substance of the kidney, we have not been able to observe any continuous pervading structure of fibro-cellular tissue. The apparently reticular framework which is displayed by washing a thin slice of the kidney has seemed to us to be formed by the basement-membrane of the transversely or obliquely cut tubes, deprived of epithelium and connected by a transparent tissue, which is doubtless made up principally of vessels (although in the uninjected state, these do not definitely appear) and has granular corpuscles irregularly dispersed in it.

summit of the kidney, to which it is connected by loose cellular tissue, is thick, and almost always deeply grooved. The *posterior* surface rests upon the diaphragm. Its *anterior* surface is covered on the right side by the liver, and on the left by the pancreas and spleen. The inner border of the right supra-renal capsule is in contact with the vena cava inferior, and that of the left with the aorta. The right capsule, like the right kidney, is placed lower down than the left.

The supra-renal capsules vary in *size* in different individuals, and the left is usually somewhat narrower at its base, but is longer from above downwards, and usually larger than the right. They measure from an inch and a quarter to an inch and three quarters in height, and about an inch and a quarter in width; their thickness is from two to three lines. The *weight* of each supra-renal capsule in the adult is from one to two drachms.

Besides cellular tissue mixed frequently with much fat, the supra-renal capsules have a thin fibrous investment, which also sends numerous processes into their interior, accompanied by many blood-vessels. These processes enter certain furrows, varying in depth and extent, by which the surface of the organ is marked, especially in front and upon its base. Externally, the supra-renal capsules have a yellowish or brownish-yellow colour; but, when divided, they seem to consist of two substances, viz., one *external* or *cortical*, which is of a deep yellow colour, firm and striated, and forms the principal mass of the organ; the other *internal*, which is dark, soft, pulpy, and of a brownish-black hue. Many anatomists describe a cavity within this soft central substance, but some attribute the seeming cavity to accidental laceration of the soft substance, while others look upon it as a venous sinus. The name of atrabiliary capsules, given to these organs, has reference to the dark, black colour of their interior.

The *cortical* striated part of the supra-renal capsules has been found, by Mr. Simon, to consist of distinct closed tubes, arranged in columnar masses, perpendicularly to the surface of the organ. These tubes measure, on an average, about $\frac{1}{700}$th of an inch in diameter. They have no communication with one another, but each consists of a very delicate constituent membrane, which is complete on all sides. The small blood-vessels run parallel to these tubes, frequently anastomose together between them, and surround each tube with a fine capillary network. In the interior of the tubes, are found nucleus-like bodies, mixed with minute yellowish granules, and oily particles with granular matter adhering to them, also nucleated cells containing granular matter and oily molecules. According to Mr. Gulliver's observations, the nucleated corpuscles or cells always exist, in large numbers, in the supra-renal bodies of ruminant animals, but they occur more sparingly in the human subject, and in other animals. They resemble the lymph globules in size, but are often of a reddish colour. The *granules*, or minute *spherules* (Gulliver) form, however, the chief constituents of the substance of the supra-renal gland. Their size is very unequal, varying from $\frac{1}{5000}$th to $\frac{1}{24000}$th of an inch, and averaging about $\frac{1}{10000}$th of an inch. Their great peculiarity consists

in their undergoing no change when treated by chemical reagents, (acids, alkalies, and salts,) excepting after the lapse of a considerable time. The *dark* pulpy *portion* contained in the *interior* of the supra-renal body seems to be principally composed of a plexus of minute ramified veins, surrounded by the peculiar substance of the organ, and having sometimes amidst them a central venous sinus. Mr. Gulliver has frequently found in the blood of the supra-renal veins numerous minute spherules, which could not be distinguished from those of the glands.

No excretory duct has been found connected with these organs, the office of which is entirely unknown.

Vessels.—The supra-renal bodies receive *arteries* from three sources, viz., from the aorta, the phrenic, and the renal arteries. The distribution of their capillary vessels has already been mentioned.

The *veins*, which pass out from the centre, are usually united into one for each organ. The right vein enters the vena cava inferior immediately, whilst the left, after a longer course, terminates in the left renal vein.

The *lymphatics* are but little known.

Nerves.—The nerves are exceedingly numerous. They are derived from the solar plexus of the sympathetic, and from the renal plexuses. According to Bergmann, some filaments come from the phrenic and pneumogastric nerves.

THE URETERS.

The *ureters* are two nearly cylindrical tubes, one right, the other left, which conduct the urine from the kidneys into the bladder. The upper, dilated, funnel-shaped end of these excretory ducts, called the *pelvis of the kidney*, together with its branches and their ultimate divisions, named the *calices*, have already been described (p. 509). Towards the lower part of the hilus of the kidney, the so-called pelvis becomes gradually contracted, and, opposite the lower end of the gland, assumes the name of *ureter*, which extends downwards from thence to the posterior and under part or base of the bladder, into which viscus the ureters of both sides open, after passing obliquely through its coats.

The ureters measure from sixteen to eighteen inches in length, and their ordinary width is about that of a large quill. They are frequently, however, dilated at intervals, especially near their lower end. The narrowest part of the tube, excepting its orifice, is that contained in the walls of the bladder.

Each ureter (fig. 478, *u*,) passes, at first, obliquely downwards and inwards, to enter the cavity of the true pelvis, and then curves downwards, forwards, and inwards, to reach the side and base of the bladder (*a*). In its whole course, it lies close behind or beneath the peritoneum (*r*), and is connected to neighbouring parts by loose cellular tissue. Superiorly, it rests upon the psoas muscle, and is crossed, very obliquely, below the middle of the psoas, by the spermatic vessels, which descend in front of it. The right ureter is close to the inferior vena cava. Lower down, the ureter passes over the

common iliac, or the external iliac vessels, behind the termination of the ileum on the right side and the sigmoid flexure of the colon on the left. Descending into the pelvis, and, entering the fold of peritoneum, forming the corresponding posterior false ligament of the bladder, it gains the lateral part of the base of that viscus, upon which it runs downwards and forwards, below the obliterated hypogastric artery, and crossed upon its inner side, in the male, by the vas deferens (*i*), which passes down between the ureter and the bladder. In the female, the ureters run along the sides of the cervix uteri, and upper part of the vagina before reaching the bladder, and hence they are proportionally somewhat longer than in the male.

Having reached the base of the bladder on each side, about two inches apart from one another, the ureters (fig. 479,[5]) enter its coats, and running obliquely through them for nearly an inch, passing at first through the muscular coat, and then between it and the mucous membrane, open at length upon the inner surface by two narrow and oblique slit-like openings, which are situated, in the male, about an inch and a half behind the prostate, and rather more than that distance from each other. This oblique passage of the ureter through the vesical walls, although allowing the urine to flow into the bladder, has the effect of preventing its return up the ureter towards the kidney.

Structure.—The walls of the ureter are pinkish or bluish white in colour. They consist externally of a dense, firm, cellular coat, which in quadrupeds decidedly contracts when artificially irritated, and probably contains pale muscular fibres. According to Huschke, it consists of two layers of longitudinal fibres, with an intermediate one composed of transverse fibres. It becomes continuous above at the calices, with the proper capsule of the kidney.

Internally, the ureter is lined by a thin and smooth *mucous membrane*, which presents a few longitudinal folds when the ureter is laid open. It is prolonged above upon the papillæ, and into the uriniferous tubes, and below becomes continuous with the lining membrane of the bladder. The epithelial particles are of the spheroidal or transitional form.

Vessels.—The ureter is supplied with blood from small branches of the renal, the spermatic, the internal iliac, and the inferior vesical arteries. The veins end in various neighbouring vessels. The *nerves* come from the inferior mesenteric, spermatic, and hypogastric plexuses.

Varieties.—Sometimes there is no funnel-shaped expansion of the ureter at its upper end into a pelvis, but the calices unite into two narrow tubes, which afterwards coalesce. Occasionally, the separation of these two tubes continues lower down than usual, and even reaches as low as the bladder, in which case the ureter is *double*. In rare cases, a triple ureter has been met with.

THE URINARY BLADDER.

The *urinary bladder* (vesica urinaria) is the hollow membranous and muscular viscus which receives the urine poured into it through the ureters, retains it for a longer or shorter period, and finally expels it through the urethra.

During infancy it is pyriform, and is found in the abdomen, but in

the adult (fig. 478, *a*,) it is situated in the pelvic cavity behind the pubes (*g*), and in front of the rectum (*b*) in the male; but separated from that intestine by the uterus and vagina in the female.

Fig. 478.

Lateral view of the viscera of the male pelvis. (Quain's Arteries, Pl. LX.) *a.* Bladder. *b. b'.* Rectum. *c.* Membranous portion of the urethra. *d.* Section of left crus, or corpus cavernosum. *e.* Bulbous extremity of corpus spongiosum or bulb of urethra. *f.* Cowper's gland. *g.* Section of body of pubes. *h.* Sphincter ani muscle. *i.* Part of left vas deferens. *m.* Articular surface of sacrum. *n.* Spine of left ischium sawn off. *o.* Coccyx. *p.* Prostate gland. *r, r.* Peritoneum. *r'.* Cul-de-sac between bladder and rectum. *u.* Left ureter. *v.* Left vesicula seminalis.

The *size* and *shape* of the bladder, its *position* in the abdomino-pelvic cavity, and its *relations* to surrounding parts, vary greatly, according to its state of distension or collapse. When quite empty, the bladder lies deeply in the pelvis, appearing as a triangular sac, flattened before and behind, having its base turned downwards and attached, whilst its apex reaches up behind the symphysis pubis. When slightly distended, it is still contained within the pelvic cavity, and has a rounded form; but when completely filled, it rises above the brim of the pelvis, and becomes ovoidal, or egg-shaped, its larger end, which is also called the *base*, or *inferior fundus*, being directed downwards and backwards towards the rectum in the male and the vagina in the female; and its smaller end or *summit*, or *superior fundus*, pointing towards the lower part of the anterior wall of the abdomen. The long axis of the distended bladder is therefore inclined obliquely upwards and forwards from the base to the summit, in a line directed from the coccyx to some point between the pubes and the umbilicus. In being gradually distended, the bladder curves slightly forwards, so that it becomes more convex behind than in front, and its upper end is by degrees turned more and more towards the front of the abdomen. Lastly, the bladder, when filled, appears slightly compressed from before backwards, so that its diameter in that direction is less than

from side to side. Its longest diameter in the male is from base to summit, but in the female, its breadth is greater than its height; and its capacity is said to be, on the whole, larger than in the former sex. The portion of the bladder situated between the base and the summit is often called the *body*.

At the lower part of the anterior surface of this organ, immediately in front of the base, is a narrow funnel-shaped portion, named the *cervix*, or *neck*, which forms the outlet of the bladder, and serves also to attach it below to the urethra. While freely movable in all other directions upon surrounding parts, the bladder is still further fixed below to the inside of the pelvis, by certain reflections of the recto-vesical fascia, named the *true ligaments* of the bladder. It is supported, moreover, by firm cellular connexions with the rectum or vagina, according to the sex, also by the two ureters, the obliterated hypogastric arteries, and the *urachus*, by numerous blood-vessels, and, lastly, by a partial covering of the peritoneum, which, as it is being reflected to or from this organ in different directions, forms certain folds or duplicatures, named the *false ligaments* of the bladder. All these parts will now be separately described, as well as the relations of the different surfaces of the bladder itself, supposed to be moderately distended.

The *anterior* surface is entirely destitute of peritoneum, and is placed behind the triangular ligament of the urethra, the sub-pubic ligament, the symphysis and body of the pubes, and, if the organ be full, the lower part of the anterior wall of the abdomen. It is connected to these parts by loose cellular tissue, and to the back of the pubes by two strong bands of the vesical fascia, named the *anterior* true ligaments. This surface of the bladder may be punctured above the pubes without wounding the peritoneum. In the female, the front of the bladder corresponds, beneath the arch of the pubes, with the part of the vulva between the orifice of the urethra and the clitoris.

The *summit* (sometimes named the *superior fundus*) is connected to the anterior abdominal wall by a median cord, named the *urachus*, which is composed of fibro-cellular tissue, mixed near the bladder with some muscular fibres. This cord, which becomes narrower as it ascends, passes upwards from the apex of the bladder behind the linea alba, and in front of the peritoneum, to reach the umbilicus, where it becomes blended with the dense fibrous tissue found in that situation. The urachus is the vestige of a fœtal structure, to which we shall have again to advert. Two other rounded cords formed by the obliterated hypogastric arteries, and found, one on each side of the urachus, also ascend from the bladder to the umbilicus. In front of these three cords, the summit of the bladder has no peritoneal covering, and when the viscus is filled, touches the abdominal parietes. Behind them, on the other hand, it receives a covering from that serous membrane, and has a few convolutions of the small intestine resting upon it.

The *posterior surface* of the bladder is entirely free, and covered everywhere by the peritoneum (*r*), which is prolonged also for a short distance upon the base of the bladder. In the male, this surface is in

contact with the rectum (*b*), and in the female with the uterus, some convolutions of the small intestine descending between it and those parts, unless the bladder be very full. Beneath the peritoneum, on each side of the lower portion of this surface, is found a part of the vas deferens (*i*).

The *sides* of the bladder, which, when it is distended, are rounded and prominent, are each of them crossed obliquely by the cord of the obliterated hypogastric artery, which springs posteriorly from the superior vesical artery, and runs forwards and upwards towards the summit of the bladder. Behind and above this cord the side of the bladder is covered by the peritoneum, but below and in front of it the peritoneum does not reach the bladder, which is here connected to the sides of the pelvic cavity by loose cellular tissue, containing fat, and, near its anterior and lower part, by a broad expansion from the vesical fascia. The vas deferens (*i*) crosses over the lower part of this lateral surface, from before, backwards and downwards, and turning over the obliterated hypogastric artery, descends upon the inner side of the ureter (*u*) along the posterior surface to the base of the bladder.

The *base* or *fundus* (bas fond; inferior fundus) is the widest and most depending part of the bladder, and demands special attention. It is directed somewhat backwards as well as downwards, and differs in its relations to other parts according to the sex. In the *male*, it rests upon the second portion of the rectum (*b′*), and is covered posteriorly for a short space by the peritoneum, which, however, is soon reflected backwards from it upon the rectum, so as to form the *recto-vesical* pouch or *cul-de-sac* (*r′*). In front of the line of reflection of the serous membrane, the base of the bladder presents a triangular surface, destitute of peritoneum, and separated from the rectum by some dense fibro-cellular tissue only, which adheres to both organs. This triangular surface (fig. 479), is bounded at the sides by the vasa deferentia ([7]) and vesiculæ seminales ([9]), which are here firmly attached to the bladder, as they converge forwards to the prostate gland ([3]); behind, it is limited (at the lower line [2]) by the reflection of the peritoneum at the cul-de-sac, whilst its apex in front touches the prostate gland. It is in this space, which in the natural state of the part is by no means so large as it appears after they are disturbed in dissection, that the bladder may be punctured from the rectum without injury to the peritoneum. In the

[Fig. 479.

The base of the male bladder, with the vesiculæ seminales and prostate gland. 1. The urinary bladder. 2. The longitudinal layer of muscular fibres. 3. The prostate gland. 4. Membranous portion of the urethra. 5. The ureters. 6. Blood-vessels. 7. Left; 8. Right vas deferens. 9. Left seminal vesicle in its natural position. 10. Ductus ejaculatorius of the left side traversing the prostate gland. 11. Right seminal vesicle injected and unravelled. 12, 13. Blind pouches of vesiculæ. 14. Right ductus ejaculatorius traversing the prostate.—(Haller.)]

female, the base of the bladder is of less extent, and does not reach so low down in the pelvis as in the male; for it rests against the lower part of the anterior surface of the uterus and the anterior wall of the vagina, both of which organs intervene between it and the rectum. This part of the bladder adheres to the vagina, but the peritoneum forms a pouch between it and the uterus.

The *cervix* or *neck* of the bladder, situated at the lower part of the anterior surface, and immediately in front of the base, is the constricted portion which is directly continuous with the urethra. In the female it is free, being merely surrounded by cellular tissue and blood-vessels, but in the male it becomes encircled by the prostate gland. In the male also, it is nearly horizontal, or even slightly oblique in an upward direction, owing to the fundus of the bladder being on a somewhat lower level, but in the female its direction is obliquely downwards and forwards, for the cervix is the lowest part of the female bladder, and such is also the case in male infants. The neck of the bladder is supported in front and at the sides by the vesical fascia.

Ligaments of the bladder.—The *true ligaments* of the bladder, four in number, two anterior and two lateral, are all derived from the vesical portion of the recto-vesical fascia. The *anterior ligaments*, one right, the other left, are two strong whitish bands, which pass from the back of the pubes to the front of the neck and lower part of the anterior surface of the bladder. A few of the pale vesical muscular fibres are prolonged into them, and hence they are considered by some as tendons of attachment for the muscular fibres of the bladder. In the male, these anterior ligaments (*pubo-prostatic* ligaments), in passing backwards, first reach the upper surface of the prostate and cover in the anterior fibres of the levatores ani, which spread out on that gland and form the levatores prostatæ. Between the two ligaments is a cellular interval, in which are found the dorsal vein of the penis, or of the clitoris. The *lateral ligaments*, much broader and thinner than the anterior, are the lateral portions of the vesical fascia, which proceed inwards to be fixed to the neck and side of the bladder, and (in the male) to the side of the prostate.

Peritoneal folds or *false* ligaments.—These are five in number. Two of them, named *posterior false ligaments*, or *recto-vesical* folds, (plicæ semilunares, Douglas,) run forward in the male along the sides of the rectum to the posterior and lateral aspect of the bladder, curving upwards when this latter is distended, and bounding the sides of the recto-vesical cul-de-sac of the peritoneum. In the female, these posterior folds pass forward from the sides of the uterus, and are comparatively small. The two *lateral* false ligaments extend from the iliac fossæ to the sides of the bladder; the *superior* false ligament (ligamentum suspensorium) formed by the projection of the ascending part of the epigastric arteries and the urachus, into a duplicature of the peritoneum, reaches from the summit of the bladder to the umbilicus.

Internal surface.—On opening the bladder its internal surface is found to be lined by a smooth membrane, which is so loosely attached to the other coats, that in the flaccid condition of the organ it is

nearly everywhere thrown into small wrinkles or folds, which disappear so soon as the bladder is distended. Besides these, the interior of the bladder is often marked by reticular elevations or ridges, corresponding with the fasciculi of the muscular coat.

At the lower and anterior part of the bladder is seen the *orifice* leading from its neck into the urethra, around which the mucous membrane is corrugated longitudinally (see fig. 484). Immediately behind the urethral opening, at the anterior part of the fundus, is a small smooth triangular surface, having its apex turned forwards, which, owing to the firmer adhesion of the mucous membrane to the subjacent tissues, never presents any rugæ, even when the bladder is empty. This surface is named the *trigone* (trigone vesical; trigonum vesicæ, Lieutaud); at its posterior angles are the orifices of the two ureters, situated about $1\frac{3}{4}$ inch from each other, and about $1\frac{1}{2}$ inch from the anterior angle, which corresponds with the opening into the urethra. At the last-named point is found a slight elevation of the mucous surface, named the *uvula vesicæ* (luette vesicale), which projects from below into the urethral orifice. In the female, the trigone is small, and the uvula indistinct. In the male, this last-named elevation lies a little in advance of the middle lobe of the prostate, and is sometimes prolonged on the floor of the prostatic portion of the urethra. It is formed by a thickening of the submucous tissue. It can scarcely act as a valve to the urethral orifice, but it is sometimes very much enlarged, and then obstructs that passage.

The *sides* of the trigone, especially when the muscular coat of the bladder is strong, are bounded by two slight ridges, which pass obliquely backwards and outwards to the orifices of the ureters, and indicate the course of two small bundles of muscular fibres. A prolongation of each of these ridges beyond the openings of the ureters is sometimes seen, caused, it would appear, merely by the lower ends of those canals, as they pass obliquely through the parietes of the bladder. The *posterior* boundary of the trigone is slightly curved, its concavity being directed backwards.

Structure.—The bladder is composed of a *serous*, a *muscular*, and a *mucous* coat, united together by cellular tissue, and supplied with vessels and nerves.

The *serous* or *peritoneal* coat is a partial covering, investing only the posterior and upper half of the bladder, and reflected from its summit, sides, and under surface, in the manner already described in detail.

The *muscular* coat.—This consists of bundles of pale unstriped involuntary muscular fibres, which are arranged in two principal but imperfect layers, distinguished, from their position and direction, into the *external* or longitudinal, and the *internal*, transverse or circular.

The *external* or *longitudinal* fibres are most distinctly marked on the *anterior* and *posterior* surfaces of the bladder. Commencing in front from the neck of the organ, from the anterior true ligaments, and, in the male, from the adjoining part of the prostate gland, they may be traced upwards along the anterior surface to the summit of the bladder, whence they may be followed down over the posterior

surface and base to the under part of the neck of the bladder, where they become attached to the prostate in the male, and to the front of the vagina in the female. Upon the *sides* of the bladder the longitudinal fasciculi run more or less obliquely, and often intersect one another: in the male they reach the sides of the prostate. At the summit a few are continued along the urachus. The longitudinal fibres, taken together, constitute what has been named the *detrusor urinæ* muscle.

The *internal* or circular fibres are, for the most part, transverse, but, upon the body of the bladder are scattered very thinly and irregularly, having various arrangements in different bladders. Towards the lower part of the organ, they assume a more decidedly circular course, and upon the fundus and trigone form a tolerably regular layer. Close to and around the cervix, immediately behind the prostate in the male, they densely encircle the orifice, and constitute what has been named the *sphincter vesicæ*, which, however, is not distinct from the other circular fibres.

[According to Dr. Horner, the inferior semi-circumference of the neck of the bladder is defined by a thick fasciculus of muscular (?) fibre, having a texture resembling that of the middle coat of the arteries. The fasciculus is half an inch wide, passes transversely above the third lobe of the prostate gland, and has its extremities attached to the lateral lobes of the latter. The superior semi-circumference is surrounded by a layer of muscular fibres, forming a broad thin crescentic band, the extremities of which are downwards, and are insensibly lost by their divergence in the external layer of the general muscular investment of the bladder.* The elastic character of the transverse fasciculus in a state of rest will keep the orifice of the neck of the bladder closed, while the muscular fibres, in the general contraction of the muscular coat of the bladder, it is to be presumed, will stretch the band, and in this manner open the orifice.—J. L.]

The *muscles of the ureters* are the two muscular bundles, sometimes more clearly seen than at others (and especially in male subjects), which pass obliquely from behind the opening of the urethra, or from the uvula, backwards and outwards to the orifices of the ureters. In the male, these bundles meet behind the prostate, and there end by fibrous tissue in the middle lobe of that gland. They were known to Morgagni, but have more recently been fully described under the name of the "muscles of the ureters" by Sir C. Bell, who supposed that, during the contraction of the bladder, they might maintain the due obliquity of the lower end of the ureters, necessary to prevent reflux of urine into these tubes; others have thought that they might facilitate the flow of urine into the bladder by stretching the ureters and their orifice downwards.

The muscular coat of the bladder forms so incomplete a covering, that when the organ is much distended, intervals arise in which the walls of the organ are very thin; and should the internal or mucous lining protrude in any spot through the muscular bundles, a sort of hernia is produced, which may go on increasing, so as to form what is called a vesical sacculus, or *appendix vesicæ*, the bladder thus affected being termed *sacculated*. Hypertrophy of the muscular fasciculi, which is liable to occur in stricture of the urethra or other

* [Spec. Anat. and Hist., vol. ii. p. 103. Philadelphia, 1846.]

affections impeding the issue of the urine, gives rise to that condition named the *fasciculated* bladder, in which the interior of the organ is marked by strong reticulated ridges or columns.

Next to the muscular coat, between it and the mucous membrane, but much more intimately connected with the latter, is a well-marked layer of cellular tissue, frequently named the *cellular*, or *vascular* coat. This submucous cellular layer contains a large quantity of very fine coiled fibres of elastic tissue.

The mucous membrane of the bladder is soft, smooth, and of a pale rose-colour. It is continuous above with that of the ureters and kidneys, and below with that lining the urethra. It adheres but loosely to the muscular tissue, except at the trigone, where it is in consequence always smooth. There are no villi upon the vesical mucous membrane, but it is provided with minute follicles, which are most abundant in the vicinity of the neck of the bladder. It is covered with an epithelium, the particles of which are intermediate in form between those of the columnar and squamous varieties. The vesical mucus (according to Mandl) is alkaline, and appears to contain alkaline and earthy phosphates.

Vessels.—The *supèrior vesical* arteries are the remaining pervious portions of the hypogastrics; in the adult they appear as branches of the internal iliac. The *inferior* vesical arteries are usually derived from the anterior division of the internal iliac. The uterine arteries also send branches to the bladder in the female. The neck and base of the organ appear to be the most vascular portions. The *veins* form large plexuses around the neck, sides, and base of the bladder; they eventually pass into the internal iliac veins. The *lymphatics* follow a similar course. The *nerves* are derived partly from the hypogastric plexus of the sympathetic, and partly from the sacral plexus of the cerebro-spinal system. The former are said to be chiefly distributed to the upper part of the bladder, whilst the spinal nerves may be traced to its neck and base.

THE URETHRA.

The urethra is a membranous tube directed in the median line from behind forwards, beneath the arch of the pubes; by one extremity it is continuous with the neck of the bladder, by the other it opens externally. In the *female*, it serves simply as the excretory passage for the urine; in the *male*, it conducts also the seminal fluid.

a. The *female urethra*, as compared with that of the other sex, is very short, representing only the commencing part of the male passage. It is only about an inch and a half in length, but is wide and capable of great distension; its ordinary diameter is about three or four lines, but it enlarges towards its vesical orifice. The direction of this canal is downwards and forwards, and it is slightly curved and concave upwards. It lies embedded in the upper or rather the anterior wall of the vagina, from which it cannot be separated; the two passages both perforate the triangular ligament; the upper one, or urethra, is covered by the anterior ligament of the bladder.

The external orifice, or *meatus urinarius*, opens in the vulva, beneath

the symphysis pubis, nearly an inch below and behind the clitoris, between the nymphæ and immediately above the entrance to the vagina. It will be again noticed with the other parts in the vulva. From its orifice, which is the narrowest part of the canal, it passes upwards and backwards between the crura of the clitoris and behind the pubes, gradually enlarging into a funnel-shaped opening as it approaches and joins the neck of the bladder. There is also a dilatation in the floor of the canal, just within the meatus.

The mucous membrane is whitish, except near the orifice; it is raised into longitudinal plicæ, which are not entirely obliterated by distension, especially one which is particularly marked on the lower or posterior surface of the urethra. Near the bladder the membrane is soft and pulpy, with many tubular mucous glands. Lower down these increase in size and lie in groups, between the longitudinal folds, and immediately within and around the orifice, the lips of which are elevated, are several larger and wider crypts.

The lining membrane is covered with a scaly epithelium, but higher up near the bladder the particles become spheroidal. The submucous cellular tissue contains elastic fibres. Outside this there is a highly vascular structure, in which are many large veins. Between the anterior and posterior layers of the triangular ligament, the female urethra is embraced by the fibres of the compressor urethræ muscle, which will be hereafter described (p. 538).

The *vessels* and *nerves* of the female urethra are very numerous, and are derived from the same sources as those of the vagina.

b. The *male* urethra is much longer, and its anatomy more complex; from its additional function and anatomical connexions, the description of it is most conveniently associated with that of the organs of generation.

ORGANS OF GENERATION.

THE MALE ORGANS OF GENERATION.

The male organs of generation consist of the *testes* and their *excretory apparatus*, the *prostate* and *Cowper's glands*, and the *penis*, with the *urethra* or genito-urinary passage.

Taking the organs according to their local connexion with parts previously described, rather than in a physiological order, we commence with

THE PROSTATE GLAND.

The *prostate gland* (from προΐστημι, to stand before; fig. 478, *p*) is a firm glandular body, very much resembling a chestnut in shape and size, which surrounds the neck of the bladder and the commencement of the urethra, and is placed in the pelvic cavity, between and below the pubes and behind the triangular ligament. It has been compared to a truncated cone, compressed from above downwards, having its broader part or base turned backwards and upwards towards the neck of the bladder, and its blunted apex in the opposite direction towards the membranous part of the urethra. It usually measures about an inch and a half across at its widest part, an inch or rather more from its base to its apex, and about three quarters of an inch in depth or thickness. Its ordinary weight is about six drachms.

The anterior or upper surface of the prostate is flattened and marked with a slight longitudinal furrow: it is about half an inch or rather more beneath the pubic symphysis, and, as well as the sides of the gland, is connected to the pubic arch by a reflection of the pelvic fascia, forming the pubo-prostatic *ligaments* or *anterior ligaments* of the bladder. The posterior or under surface (fig. 479) is smooth, and is marked by a slight depression, or by two grooves, which meet in front, and correspond with the course of the seminal ducts, as well as mark the limits of the lateral lobes in this situation; it is closely united to the rectum, just before the bowel turns downwards to reach the anus, by means of cellular membrane, which is destitute of fat; so that this surface of the gland and also its posterior border, can be felt by the finger introduced into the intestine. The sides are convex and prominent, and are slung as it were by the anterior portions of the levatores ani muscles, which pass down, on either side, from the symphysis pubis and anterior ligament of the bladder, and spread out on the sides of the prostate. This part of each levator ani is occasionally separated from the rest of the muscle by cellular tissue; it has been named *levator prostatæ* (p. 472). The base of the gland is of considerable thickness, and is notched in the middle: its apex is turned

towards the triangular ligament. As already stated, the prostate encloses part of the neck of the bladder and the commencement of the urethra. The canal runs nearer to the upper than to the under surface of the gland, so that in general it is about two lines distant from the former and four from the latter; but it frequently differs greatly in this respect. The prostatic portion of the urethra is about an inch and a quarter long, and is dilated in the middle; it contains the verumontanum and the openings of the seminal and prostatic ducts, to be afterwards noticed. The common seminal ducts, which pass forwards from the vesiculæ seminales, also go through the lower part of the prostate, enclosed in a special canal, and open into the urethra. This gland is usually described as consisting of three lobes, two of which placed laterally and separated behind by the posterior notch, are of equal size; the third, or *middle* lobe, is a smaller rounded or triangular mass, intimately connected with the other two, and fitted in between them on the under side, lying beneath the neck of the bladder and the immediately adjacent part of the urethra. This third lobe is exposed by turning down the seminal vesicles and ducts, between which and the cervix vesicæ it is placed. When rather prominent in the bladder, it corresponds to the elevation already described in that organ, and named the uvula vesicæ; and when much enlarged, it projects in such a way as to impede or prevent the evacuation of the urine.

Structure.—The prostate is enclosed in a dense fibrous coat, which is continuous with the recto-vesical fascia and with the posterior layer of the triangular ligament, and is rather difficult either to tear or cut. Mr. Adams describes the fibrous capsule as divisible into two layers, between which the prostatic plexus of veins is enclosed.* The substance of the gland is spongy and more yielding; its colour is reddish gray, or sometimes of a brownish hue. It consists of numerous small follicles or terminal vesicles opening into elongated canals, which unite into a smaller number of excretory ducts. These appear as pores or whitish streaks, according to the way in which they are exposed on a section. The epithelium in the vesicular terminations is thin and squamous, whilst in the canals it is columnar. The capillary blood-vessels spread out as usual on the ducts and clusters of vesicles, and their different elements are united by areolar tissue, and supported by processes of the deep layer of the fibrous capsule (Adams). The ducts open by from twelve to twenty or more orifices upon the floor of the urethra, as will presently be noticed, together with other parts to be seen in the prostatic portion of that canal.

Vessels and Nerves.—The prostate is supplied by branches of the vesical, hemorrhoidal, and pudic *arteries.* Its *veins* form a plexus around the sides and base of the gland, which is particularly marked in old subjects. These veins communicate in front with the dorsal vein of the penis, and behind with branches of the internal iliac vein. According to Mr. Adams, the lymphatics, like the veins, are seen ramifying between the two layers of the fibrous capsule. The *nerves* are derived from the hypogastric plexus.

* Cyclop. of Anat., vol. iv., p. 147.

Prostatic fluid.—This is mixed with the seminal fluid during emission; as obtained from the human prostate soon after death, it has a milky aspect, which is ascribed, by Mr. Adams, to the admixture of a large number of epithelial cells, and he thinks it probable that, as discharged during life, it is more transparent. According to the same observer, the prostatic fluid has an acid reaction, and presents, under the microscope, numerous molecules, epithelial particles, both squamous and columnar, and granular nuclei, about $\frac{1}{3300}$ inch in diameter. As age advances, this gland is disposed to become enlarged; and its ducts often contain small round concretions about the size of a millet seed, which are composed of carbonate of lime and animal matter.

THE PENIS.

The penis, which supports the greater part of the urethra in the male, is composed principally of an erectile tissue, occupying three long and nearly cylindrical compartments, or forming three bodies (corpora), as they are termed. Of these, two, named *corpora cavernosa penis*, placed side by side, form the principal part of the organ, whilst the other, situated behind or beneath the two preceding, surrounds the canal of the urethra; it is hence named *corpus cavernosum urethræ* or *corpus spongiosum.*

The penis is attached behind to the front of the pubes, and to the pubic arch, by what is termed the *root;* in front it ends in an enlargement named the *glans.* The intermediate portion or *body* of the penis, owing to the relative position of its three compartments, has three sides, and three rounded borders; its widest side is turned upwards and forwards, and is named the *dorsum.* The entire organ is invested by the common *integument,* which will be immediately noticed. The *glans* penis, which is slightly compressed above and below, presents at its summit a vertical fissure, the external orifice of the urethra; its base, which is wider than the body of the penis, forms a rounded projecting border, named the *corona glandis,* behind which is a constriction named the *cervix;* the posterior boundary of the glans thus marked off passes down on each side of the under surface, and ends behind the urethral opening, on the sides of a median fold of skin, named the *frænum.*

The integuments.—The *prepuce* or *foreskin* (præputium) is a loose circular fold of skin, which is attached around the penis behind the cervix, and covers the glans. The integument of the penis, which is continued from that upon the pubes and scrotum, forms a close and simple investment, as far as the neck of the glans. At this part it leaves the surface and is doubled up to form the prepuce. The inner layer of this fold returns to the penis behind the cervix, where it is firmly attached, and becoming thus again adherent, is continued forwards over the corona and glans, as far as the orifice of the urethra, where it meets with the mucous membrane of the urethra, and behind that orifice forms the *frænum of the prepuce.* Upon the body of the penis the skin is very thin, entirely free from fat, and, excepting at the root, from hairs also, in these respects differing remarkably from that on the pubes, which is thick, covers a large cushion of fat, and, after puberty, is beset with hairs: the skin of the penis is moreover very movable and distensible, and is dark in colour. At the free margin of the prepuce the integument changes its character, and approaches to

that of a mucous membrane, being red, thin, and moist. Numerous lenticular glands are collected around the cervix of the penis and corona; they are named the *glands of Tyson* (glandulæ Tysoni, vel odoriferæ), and secrete a sebaceous matter of a peculiar odour (*smegma præputii*), which appears to contain caseine, and easily runs into decomposition. Upon the glans penis the membrane again changes its character; it ceases to contain glands, but its papillæ are highly developed and extremely sensitive, and it adheres most intimately and immovably to the spongy tissue of the glans.

Beneath the skin, on the body of the penis, the ordinary superficial fascia is very distinct; it is continuous with that of the groin, and also with the dartoid tissue of the scrotum. Near the root of the organ there is a dense band of fibro-elastic tissue, named the *suspensory ligament*, lying amongst the fibres of the superficial fascia; it is triangular in form; one edge is free, another is connected with the fore part of the pubic symphysis, and the third to the dorsum of the penis, with the fibrous structures of which it is blended opposite the divergence of the two corpora cavernosa.

The integuments of the penis are supplied with blood by branches of the dorsal artery of the penis and external pudic; the veins join the dorsal and external pudic veins.

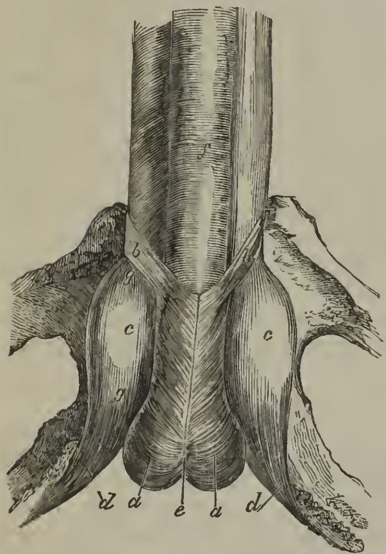
THE CORPORA CAVERNOSA.

The *corpora cavernosa* form the principal part of the body of the penis, and necessarily determine its form and consistence; and it is owing to the changes which can take place in the erectile tissue within them, that the size and direction of the organ undergo such great alterations. The two corpora cavernosa, which exactly correspond, represent two cylindrical or rather fusiform bodies, placed side by side, flattened on their median aspects, and intimately blended together along the middle line, for the anterior three-fourths of their length, whilst at the back part they separate from each other in form of two tapering processes named *crura* (fig. 480, *c*, *c*), the whole somewhat resembling the capital letter Y. Commencing behind by a pointed extremity somewhat above the tuberosities of the ischia (*d*), these crura become gradually enlarged, and are attached, one on each side, to the rami of the ischia and pubes: continuing to ascend, and then advancing from the bones, they approach and speedily become united to each other at the root of the penis. Immediately before their union each of them swells into a slight enlargement (*g* to *g*), so as to form, what are named by Kobelt, the *bulbs of the corpora cavernosa*, parts which are embraced by the erectores penis muscles (*d*), and which attain a much greater proportionate development in some quadrupeds. Beyond this point they are again slightly constricted, and are joined firmly together along the middle line to form the body of the penis, and finally becoming smaller and somewhat pointed again in front, are completely fused together into a single anterior rounded extremity, which is covered by the glans penis and closely connected to its base.

The under surface of the united cavernous bodies presents a deep

longitudinal groove, in which is lodged the corpus spongiosum (*f*), containing the greatest part of the canal of the urethra. The upper or anterior surface is also marked with a slight median groove for the dorsal vein of the penis, and near the root is attached to the pubes by the suspensory ligament.

Fig. 480.



[Fig. 481.

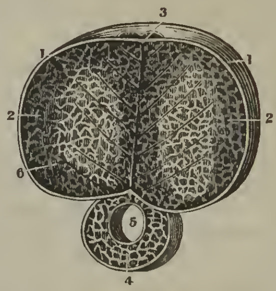


Fig. 480. Part of the ossa pubis and ischia, with the root of the penis attached (Kobelt). —*a*, *a*. Accelerator urinæ muscle, embracing the bulb of the urethra, which is slightly notched in the middle line, *e*, behind. *b*, *b*. Anterior slips of the accelerator muscle, which pass round to the dorsum of the penis. *c*, *c*. Crura of the penis. *d*, *d*. Erectores penis muscles lying on the crura. *f*. The corpus spongiosum urethræ. *g* to *g*. Enlargement of the crus, named the bulb of the corpus cavernosum.

[Fig. 481. A section of the corpora cavernosa penis (1), and corpus spongiosum urethræ (4). 2. Erectile tissue of the corpora cavernosa. 3. Septum pectiniforme. 5. Canal of the urethra. 6. Internal filaments of the corpora cavernosa which pass from the median septum to the external fibrous membrane.—S. & H.]

Structure.—A transverse section (fig. 481) through the penis, besides illustrating the structure of the cavernous bodies, shows their form and connexion with the other parts. Above, and at the sides, are seen the section of the two semi-cylindrical cavernous bodies ([1], [1]), bounded by a strong fibrous envelope, containing a mass of spongy erectile tissue in their interior, and separated by a vertical fibrous septum in the median plane ([3]). Beneath and between them is the other erectile mass, named the corpus spongiosum ([4]), surrounding the canal of the urethra ([5]).

The median septum is thick and complete behind, where the two corpora cavernosa first meet each other; but further forward it becomes thinner, and imperfectly separates their two cavities, for it presents, particularly towards the anterior extremity, numerous clefts or fissures, extending from the dorsal to the urethral edge of the septum, and admitting of a free communication between the erectile tissue of the two sides. From the direction of these slits, the intermediate white portions of the septum are made to resemble in arrangement the teeth of a comb, and hence it is named *septum pectiniforme.*

The external fibrous investment of the cavernous structure is white

and dense, from half a line to a line thick, and very strong and elastic. It is composed for the most part of longitudinal bundles of shining white fibres. It is, perhaps, the strongest fibrous tunic in the whole body, but yet it most readily admits of distension up to a certain point. The septum is composed of the same kind of fibres.

From the interior of the fibrous envelope, and from the sides of the septum, numerous lamellæ, bands and cords, composed also of an extensible fibrous tissue, and named *trabeculæ*, pass inwards and run through and across the cavity in all directions, thus subdividing it into a multitude of interstices, and giving the entire structure a spongy character. Within these interstices is lodged an intricate plexus of veins, into which the arteries open.

a. The trabeculæ, whether lamelliform or cord-like, are larger and stronger near the circumference than along the centre of each cavernous body, and they also become gradually thicker towards the crura. The interspaces, on the other hand, are larger in the middle than near the surface, and also become larger towards the fore part of the penis. The trabeculæ contain the ordinary white fibrous tissue and fine elastic fibres. A pale, reddish tissue has been observed in them by Müller and others, which has been regarded as composed of involuntary muscular fibres; this tissue is much more abundant in the penis of the horse and ass: according to Müller, it resembles muscular substance in yielding no gelatine on boiling, and in its solution in acetic acid being precipitated by the ferrocyanide of potassium.

b. The veins completely fill the intertrabecular spaces; their communications are so free and so abundant that on a section the cavernous structure appears a labyrinth of intercommunicating venous areolæ divided by the trabecular tissue. The walls of the veins are very thin, and they are lined by a squamous epithelium. The intertrabecular veins of the two sides communicate freely through the septum, especially in front; but not directly with those of the corpus spongiosum of the urethra. They return their blood partly by a series of branches which escape between the corpora cavernosa and the corpus spongiosum, and which, accompanied by veins from the latter, mount on the sides of the penis to the vena dorsalis (p. 27), partly by short veins issuing at the upper surface, and immediately joining the dorsal vein, but principally by veins passing out near the root of the penis and joining the prostatic plexus and pudendal veins. According to Kobelt, there are also communications with the cutaneous veins on the abdomen.

c. The arteries of the corpora cavernosa are branches of the pudic artery. The proper cavernous arteries (profundæ penis), right and left, supply them chiefly, but the dorsal artery of the penis also sends twigs through the fibrous sheath, along the upper surface, especially in the fore part of the penis (vol. i. p. 615). Kobelt describes a distinct small branch of the pudic artery which enters the bulbous enlargement of each corpus cavernosum; he, moreover, states that the arteriæ profundæ of the two sides form an anastomotic arch, from which the proper cavernous arteries are given off. Within the cavernous tissue, the numerous branches of the arteries are supported by the trabeculæ, in the middle of which they run (fig. 482, *a*). There is some uncertainty as to their mode of termination, but it is generally assumed that

they end in capillaries which open into minute commencing veins, as in other parts. Valentin, however, describes the minutest arterial twigs as ending by rather wide funnel-shaped orifices, which open at

Fig. 482.

Fig. 483.

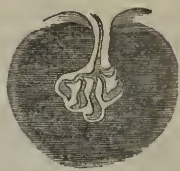


Fig. 482. Portion of the erectile tissue of the corpus cavernosum magnified, to show the areolar structure and the distribution of the arteries (Müller). *a.* A small artery, supported by the larger trabeculæ, and branching out on all sides. *c.* The tendril-like arterial tufts, or helicine arteries of Müller. *d.* The areolar structure formed by the finer trabeculæ.

Fig. 483. A single tuft or helicine artery projecting into a vein, more highly magnified (Müller).

once into the venous cavities; but this has not been confirmed. Müller has described them as terminating in two modes: according to him, some of them, which he considers as the *nutritive* arteries, end in a capillary network, which leads in the usual way to the veins; but others, which were first described by the same observer, terminate in an entirely different and peculiar way. Small ramuscles, he says, consisting of short tendril-like branches (*c*), come off from the sides of the trabecular arteries, and projecting into the vein so as to be covered by its lining membrane, end abruptly by dilated extremities (fig. 483). Sometimes they are single, and sometimes in tufts; he has named them the "helicine arteries" (arteriæ helicinæ). The existence of these little vessels was denied strenuously by Valentin, who thought they were the loose flexuous ends of the vessels of the smallest trabeculæ coiled up by the retraction of the latter after they have been broken or cut across in making a section. They may, however, be seen in the deepest cells, which have not been affected by the knife; and the observations of Krause, Hyrtl, and Erdl appear to confirm the original statement of Müller, as far at least as regards their natural existence. It was supposed by Müller that the dilated ends of these helicine arteries opened into the venous cavities, and Krause also adopts this view; but no opening has been seen in them, and as Müller himself admits, they may be merely arterial diverticula. They are most abundant in the posterior part of the corpora cavernosa, and are found in the corresponding part of the corpus spongiosum also; but they have not been seen in the glans penis. They are most distinct in man, but whatever may be their use, they do not appear to be essential to the process of erection.

CORPUS SPONGIOSUM.

The *corpus spongiosum* urethræ commences in front of the triangular ligament of the perineum, between the diverging crura of the corpora cavernosa, somewhat behind their point of junction, and below the membranous portion of the urethra, by an enlarged and rounded extremity named the *bulb* (fig. 478, *e*). From thence it extends forwards as a cylindrical, or slightly tapering body, lodged in the groove on the under side of the united cavernous bodies, as far as their blunt anterior extremity, over which it expands so as to form the glans penis already described.

The posterior bulbous extremity, or *bulb of the urethra* (figs. 478, 480, *e*), varies in size in different subjects. It receives an investment from the triangular ligament, and is embraced by the accelerator urinæ, or bulbo-cavernous muscle (*a, a*). The canal of the urethra (fig. 478, *c*) passes into the bulb behind and above, so that the latter projects below and conceals the membranous portion of that canal. This projecting part of the bulb exhibits, more or less distinctly, a subdivision into two lateral portions or lobes, between which a slight furrow externally and a slender fibrous partition internally extends for a very short distance forwards: in early infancy this is more marked. It is above and between these two halves that the urethra enters, sursounded by a portion of the spongy tissue, named by Kobelt the *colliculus bulbi*, from which a layer of venous erectile tissue passes back upon the membranous portion of the urethra, and also upon the prostatic part, to the neck of the bladder, lying closely beneath the mucous membrane. From what has preceded, it will be evident that, at first, the urethra is nearer the upper than the lower part of the corpus spongiosum, but it soon gains, and continues to occupy the middle of that body.

Structure.—This is essentially the same as that of the corpora cavernosa, only more delicate. Like the corpora cavernosa, it is distended with blood during erection; but never acquires the same hardness. The outer fibrous tunic is much thinner; the trabeculæ of the spongy tissue are finer and more equal in size, and the veins form a nearly uniform plexus between them; in the glans the meshes of this plexus are smallest and most uniform. The helicine arteries are also found in the spongy body, excepting in the part which forms the glans penis. A considerable artery, derived from the internal pudic (p. 615), enters the bulb on each side, and supplies the greater part of the spongy body, sending branches as far as the glans penis, which, however, is chiefly supplied by the arteria dorsalis. Besides these, Kobelt describes, as constantly present, another but much smaller branch of the pudic artery, which, he says, enters the bulb on the upper surface, about an inch from its posterior extremity, and runs forwards in the corpus spongiosum to the glans. *Veins* issue from the glans and adjoining part of the spongy body, to end in the vena dorsalis penis; those of the rest of the spongy body for the most part pass out backwards through the bulb, and end in the prostatic and pudic venous plexuses: some emerge from beneath the corpora cavernosa, anasto-

mose with their veins, and end partly in the cutaneous venous system of the penis and scrotum, and partly in the pudic and obturator veins.

The *lymphatics* of the penis form a dense network on the skin of the glans and prepuce, and also underneath the mucous lining of the urethra. They terminate chiefly in the inguinal glands. Deep-seated lymphatics are also described as issuing from the cavernous and spongy bodies and passing under the arch of the pubes, with the deep veins, to join the lymphatic plexuses in the pelvis.

The *nerves* of the penis are derived from the pudic and from the hypogastric plexus of the sympathetic; they are described at pp. 331 and 354.

URETHRA OF THE MALE.

The *male urethra* extends from the neck of the bladder to the extremity of the penis. Its total length has been very differently stated by anatomists, and, indeed, varies much according to the length of the penis, and the condition of that organ. An examination of a great number of cases gave as the greatest length $9\frac{1}{2}$ inches, and the least $7\frac{1}{2}$.* Its diameter varies at different parts of its extent, as will be stated more particularly in detail. The tube itself consists essentially of a continuous mucous membrane, supported by an outer layer of submucous tissue connecting it with the several parts through which it passes. In accordance with the name or character of those parts, three divisions of the urethra are separately described as the *prostatic*, *membranous*, and *spongy* portions.

1. The first, or *prostatic portion*, is the part which passes through the prostate gland. It is from 12 to 15 lines in length, is the widest part of the canal, and is larger in the middle than at either end: at the neck of the bladder its diameter is nearly 4 lines, then it widens a little, so as to be rather more than 4 lines, and in old persons 5 or 6, after which it diminishes like a funnel, until, at its anterior extremity, it is smaller than at its commencement. It passes through the upper part of the prostate, above the middle lobe, so that there is more of the gland below it than above. Though enclosed in the firm glandular substance, it is more dilatable than any other part of the urethra; but at its upper part, immediately at the neck of the bladder, it is, as elsewhere stated, much more resistant. The transverse section of the urethra, as it lies in the prostate, is triangular, the apex being turned downwards.

The lining membrane of the prostatic portion of the urethra is thrown into longitudinal folds, when no fluid is passing along it; it forms no proper valve at the neck of the bladder, but the elevation named the uvula vesicæ is sometimes seen there. Somewhat in advance of this, and along the floor of the passage, projects a narrow median ridge, about 8 or 9 lines in length, and $1\frac{1}{2}$ line at its greatest height: this ridge gradually rises into a peak and sinks down again at its anterior or lower end, and is formed by an elevation of the mucous membrane and subjacent tissue. This is the crest of the urethra

* Whately on Strictures.

(crista urethræ), more generally called *caput gallinaginis* and *verumontanum.* On each side of this ridge the surface is slightly depressed, so as to form a longitudinal groove, named the *prostatic sinus*, the floor of which is pierced by numerous foramina, the orifices of the prostatic ducts. Through these a viscid fluid oozes on pressure; the ducts of the middle lobe open behind the urethral crest, and some others open before it.

At the fore part of the most elevated portion of the crest, and exactly in the middle line, is a recess usually named the *sinus pocularis*, upon or within the margins of which are placed the slit-like openings of the common seminal, or ejaculatory ducts, one at each side. This median depression was described by Morgagni, who found it distinctly present in twelve out of fifteen cases;* and it has been generally noticed by anatomists and surgical writers since his time, but it has lately attracted renewed attention, as being the probable analogue of the uterus in the other sex. With this view it has been examined by Weber, and named by him *vesica prostatica*:† by Huschke it is more appropriately designated the *utricle* (utriculus).‡ It forms a cul-de-sac running upwards or backwards, from three to five lines deep, and usually about one line wide at its entrance and for some distance up, but acquiring a width of at least two lines at its upper end or fundus. The prominent walls of the narrow portion form the urethral crest, and its fundus appears to lie behind and beneath the middle lobe, and between the two lateral lobes of the prostate. Its parietes, which are distinct, and tolerably thick, are composed of fibrous tissue and mucous membrane, and inclose on each side the ejaculatory duct; numerous small glands open on its inner surface. According to Kobelt and others, the caput gallinaginis contains some well-marked erectile tissue, and it has been supposed that this eminence when distended with blood, may offer an obstacle to the passage of the semen backwards into the bladder.

2. The *membranous* portion of the urethra (fig. 478, *c*), comprises the part between the apex of the prostate, and the bulb of the corpus spongiosum. It measures three quarters of an inch or an inch along its upper, but only about half an inch on its lower surface, in consequence of the projection backwards of the bulb beneath it. This is the narrowest division of the urethra. It is placed beneath the pubic arch, the upper concave surface being distant nearly an inch from the bone, leaving an interval, occupied by the dorsal vessels and nerves of the penis, by cellular tissue, and some muscular fibres. Its lower convex surface is turned towards the perineum, opposite to the point of meeting of the transverse muscles: it is separated by an interval from the last part of the rectum. About a line in front of the prostate, at a distance of nearly an inch below the pubic arch, the membranous part of the urethra passes through the posterior layer of the triangular ligament of the urethra, and is then placed between that and the

* Adversaria Anat. iv. animad. 3, p. 6.

† E. H. Weber, Zusätze zur Lehre vom Baue und Verrichtungen der Geschlechts-Organe, 1846.

‡ Sœmmerring's Anatomie, vol. v.

anterior layer, through which it passes some way further forwards, but both of these fibrous membranes are prolonged upon the canal, the one backwards and the other forwards. Between these two layers the urethra is surrounded by a little erectile tissue, by some veins, and also by the fibres of the *compressor urethræ* muscle: beneath it, on each side, are Cowper's glands. This portion of the urethra is more forcibly acted on by muscular structure, in consequence of the surrounding muscular fibres immediately investing its outer surface.

3. The *spongy portion* of the urethra, by far the longest and most variable in length and direction, includes the remainder of the canal, or that part which is surrounded by the erectile tissue of the corpus spongiosum. Continuing from the membranous part, it ascends at first in front of the symphysis pubis, and then bends downwards and descends to the extremity of the penis. Its length is about six inches; and its form and diameter vary at different parts. Thus the part contained within the bulb, sometimes distinguished as the *bulbous portion*, is somewhat dilated, especially on its floor. The succeeding portion, as far as the glans, is of uniform size, being intermediate in this respect between the bulbous and membranous portions, and averaging three lines or upwards. Seen upon a cross section it appears like a transverse opening. The part situated in the glans has, on the contrary, a vertical direction on a section, and is again considerably dilated, forming what is named the *fossa navicularis*, which is about four or six lines in length, and is most evident in form of a depression on the floor of the urethra.

Lastly, at its orifice, which is a vertical fissure about two and a half to three lines in extent, and bounded by two small lips, the urethra is again contracted and reaches its narrowest dimensions. In consequence of its form, and also of the resistant nature of the tissues at its margin, this opening does not admit so large an instrument as even the membranous portion of the canal.

General direction of Urethra.—Considered as a whole in the flaccid condition of the penis, the urethra describes two curves, so as somewhat to resemble an italic *S*; the prostatic portion runs downwards and forwards,—the membranous portion curves upwards, diverging from the rectum at a considerable angle,—the bulbous portion continues to ascend, and lastly, having bent down again in front of the pubes, the remainder of the spongy portion descends. When the penis is in a state of erection, the urethra describes only a single curve, having its concavity turned upwards. From the details already given, it will further be seen that there are *three* dilatations along the course of the urethra; viz., the prostatic sinus, the bulbous sinus, and the fossa navicularis.

Mucous Membrane.—The lining membrane of the urethra, which forms a part of the genito-urinary mucous membrane, is continuous, on the one hand with that of the bladder, ureters, and kidneys, and on the other with the integument of the glans penis; it is also prolonged, as it were, throughout the whole length of the seminal, prostatic, and other ducts. It is whitish opposite the prostate, but redder further down; in the variable parts of the urethral canal it is thrown into

longitudinal folds, which disappear during the state of distension. The seminal and prostatic ducts open into the prostatic portion. In the bulbous portion, near its anterior end, are the two openings of the ducts of *Cowper's glands*.

These little glands themselves (fig. 478, *f*,) are seated further back than the bulb, beneath the fore part of the membranous portion of the urethra, between the two layers of the triangular ligament, the anterior layer supporting them against the urethra. The arteries of the bulb pass above, and the transverse fibres of the compressor urethræ beneath these glands. They are two small firm rounded bodies, about the size of peas, and of a deep yellow colour. They are compound vesicular or racemose glands, composed of several small lobules held together by a firm investment. The branched ducts, which commence in cellular crypts, unite to form a single excretory duct for each gland, which runs forwards with its fellow for about an inch and a half beneath the mucous membrane, and the two terminate in the floor of the bulbous part of the urethra by two minute orifices opening obliquely. These glands secrete a viscid fluid, the use of which is not known; their existence is said not to be constant, and they appear to diminish in old age: sometimes there is only one such gland.

Occasionally a third glandular body is found situated in front of and between Cowper's glands; this has been named the *anterior prostate* or *anti-prostatic gland*.

The whole lining of the urethra is, moreover, beset with simple mucous glands and follicles, varying much in size. Besides these, there are larger recesses or lacunæ, opening by oblique orifices turned forwards or down the canal. These are most abundant along the floor of the urethra, especially in its bulbous part. One large and conspicuous recess, situated on the upper surface of the fossa navicularis, is named the *lacuna magna*.

MUSCLES OF THE PENIS AND URETHRA.

Erector penis, or *ischio-cavernosus* (figs. 460, 507, 508, *c*, *c*; fig. 480, *d*, *d*).—This muscle embraces the unattached surface of the crus penis, and is curved to correspond. It arises behind the extremity of the crus penis from the tuber ischii (on the inner aspect of the bone), and also along the inner and the outer side of the crus, from the corresponding margins of the ramus of the pubes. From these points of origin the fleshy fibres are directed forward to a tendinous expansion, which is spread over the lower surface of the crus penis at its fore part.

This muscle serves to compress the erectile tissue, with which its tendinous fibres are connected, and thus it contributes to produce, or at least maintain, the erection of the penis.*

* By Krause the muscles of the two sides have been described as in some cases connected by a thin tendinous expansion, which, according to that anatomist, extends along the outer side of the penis over the dorsal surface of the organ, and at the same time over the vessels lying upon it (Müller's Archiv. 1832), but this connexion between the muscles has been in vain sought for by Theile and Kobelt (Die männlichen und weiblichen Wollust Organe, 1844). Mr. Houston has also described (Dublin Hosp. Reports, vol. v.), under the name of *compressores venæ dorsalis penis*, two slips of muscle, separated from the erec-

Accelerator urinæ—ejaculator seminis, or bulbo-cavernosus (figs. 460, 507, 508, *b*, *b*; fig. 480, *a*, *a*).—This is a single muscle, consisting of two symmetrical parts, which together surround a portion of erectile structure of the penis, the fibres being connected at both ends.

The fleshy fibres of the muscle take origin from the central tendon of the perineum (by means of which structure the accelerator is connected with the sphincter ani, together with the two transverse muscles), and from the median tendinous raphé (*e*) interposed between the two halves of the muscle. The larger number of the fibres is directed round the bulb and adjoining part of the corpus spongiosum urethræ, and those from opposite sides are joined above that body by a strong aponeurosis. At its fore part, a portion of the muscle (*b*, *b*) passes over the sides of the corpus cavernosum, to the dorsum of the penis, to be inserted into a fascia, which covers the dorsal vessels of the organ. The fibres which invest the posterior and most prominent part of the bulb are concealed, more or less, by those contiguous to them; hence they have been described as constituting a deep layer of the muscle. This muscle compresses the bulb and adjoining part of the corpus spongiosum of the urethra so as to evacuate fluid lodged in the canal, as well as increase the turgescence of the glans during erection.

The *transverse muscle* of the perineum (figs. 460, 507, *d*, *d*) arises from the inner surface of the ascending ramus of the ischium, and is directed transversely or obliquely forwards and inwards to join with the muscle of the opposite side, as well as with the sphincter ani and accelerator urinæ at the middle of the perineum; the several muscles being connected by fibrous or dense cellular tissue, which is known as the central tendon of the perineum. This muscle supports the perineum, and is accessory to the levator ani. It is said to be sometimes wanting.

Besides the transverse muscle, one or more small slips of muscular fibres are occasionally found on the same plane with it, and connected at one end like that muscle with the bone, while by the other end some slips are joined with the fibres of the accelerator urinæ (or constrictor vaginæ in the female), and others with the external sphincter ani.

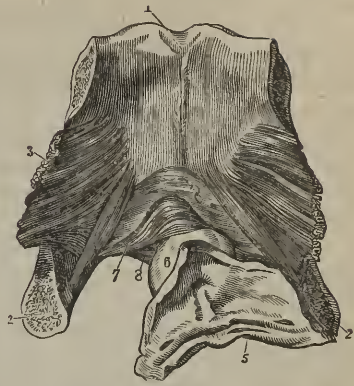
Muscular fibres of the urethra.—With the membranous portion or isthmus of the urethra of the male is connected a considerable mass of muscular structure, to which the general term of "compressor of the canal" is applicable; but it consists of parts which will be noticed separately. The whole is placed between the layers of the triangular ligament or the deep perineal fascia, with the arteries of the bulb and Cowper's glands.

Compressor urethræ (new muscles of the membranous part of the urethra, Guthrie; compressor isthmi urethræ, constrictor urethræ membranaceæ, Müller).—This muscle consists of two strata (fig. 484, [7],[8]),

tores penis on each side by an interval, though apparently belonging to them. They are said to arise from the rami of the pubes, above the origin of the erector muscles and crura of the penis, and, ascending forwards, are inserted above the dorsal vein, by joining each other in the middle line. The presence of such muscular slips in the human subject must be very rare.

one of which passes transversely above the urethra, while the other is beneath the canal. The two layers are fixed together to the ramus of the pubes on each side by narrow ends; in the middle they are connected respectively with the upper and the lower surface of the urethra, on which they are expanded so as to cover the membranous portion of the canal in its whole length. In some bodies a tendinous raphé, placed over the middle of the urinary canal, separates each stratum into lateral halves; in such cases the fibres may be said to arise from the bone on each side, and to be inserted at the median raphé, where those of opposite sides join. The fibres of the lower part of the muscle cover Cowper's glands.

Fig. 484.



Posterior view of the pubes, with part of the bladder and urethra attached (Santorini).—1. Body. 2. Ramus of the left os pubis. 3. Obturator internus muscle. 5. Portion of the fundus and neck laid open, showing the orifices of the ureters, the opening leading into the urethra, and the part called the trigone. 6. The prostate gland. 7. Transverse fibres of the compressor urethræ muscle, passing above the urethra. 8. Similar fibres passing beneath that canal.

In the female, the compressor urethræ muscle has a precisely similar arrangement.

Circular fibres, Santorini (stratum internum circulare, Müller).—A series of circular muscular fibres encircles the entire of the membranous part of the urethra, beneath the transverse muscle just described.

Wilson's muscles (m. pubo-urethrales).—By this name are known two small triangular bundles of muscular fibres arising each by a tendon, which "is affixed to the back part of the symphysis of the pubes, in the adult about an eighth of an inch above the cartilaginous arch of the pubes, and nearly at the same distance below the attachment of the tendon of the bladder."* The tendons give rise to muscular fibres, which expand as they descend, and are connected on the membranous part of the urethra with the muscular structure above described, one of the muscles being placed at each side of the urethra.

The transverse compressor of the urethra was known to Santorini. One of the representations of it, contained in his posthumous work,† has been copied for the wood-cut. Indistinctly or partially noticed by other anatomists, the muscle was first fully described by Mr. Guthrie;‡ and the whole of the muscular structure con-

* A description of two muscles surrounding the membranous part of the urethra, by James Wilson, in Medico-Chirurg. Trans. vol. i. p. 176 (with a plate). London, 1809.

As regards Wilson's muscles:—Professor Müller, after careful examination made in many bodies, satisfied himself that there are no muscular fibres directed downwards from the pubes in the manner assigned to these muscles. Mr. Guthrie arrived at the same conclusion. Still, as Wilson's statement and delineation are very clear, and as in one case I myself saw a few vertical muscular fibres connected with the transverse compressor, it has been thought best to retain the muscles in the text. (R. Q.)

† Septemdecim Tabulæ.

‡ The Anatomy and Diseases of the Neck of the Bladder, &c., 1834.

nected with the membranous part of the urethra was about the same time investigated by Professor Müller; but the results were not published till a later period.*

THE TESTES AND THEIR EXCRETORY APPARATUS.

The *testicles* or *testes*, the two glandular organs which secrete the seminal fluid, are situated in the scrotum, each being suspended by its spermatic cord.

The *spermatic cord.*—The parts which form this cord are the excretory duct of the testicle, named the vas deferens, the spermatic artery and veins, lymphatics, nerves, and connecting cellular tissue. Besides this, both the cord and the testis have several coverings.

The spermatic cord, thus composed, extends from the internal abdominal ring (vol. i. p. 303) to the back part of the testicle. Its upper portion lies in the inguinal canal, an oblique passage formed in the lower part of the abdominal walls, and is directed downwards, inwards, and forwards; but, on escaping from that canal on the external abdominal ring, (vol. i. p. 415,) it descends nearly vertically over the front of the pubes into the scrotum. The construction of the inguinal canal, the connexions of the spermatic cord in passing through it, and the relation of both to inguinal hernia, will be considered in the account of the "inguinal region."

COVERINGS OF THE TESTIS AND CORD.

Originally, and nearly up to the seventh month of fœtal life, the testes, with their ducts and vessels, are situated at the back part of the abdomen, behind the peritoneum. About the last-mentioned period each testicle enters the corresponding inguinal canal, and, followed by the spermatic cord, passes into the scrotum. During this change of position, the testis and cord become invested with certain *coverings*, as they are called, derived partly from the serous, muscular, and fibrous layers of the abdominal parietes, and partly from the proper tissues of the scrotum. These coverings, as found in the adult, and as enumerated from without inwards, are, after the *skin*, superficial fascia, and *dartos tissue* of the scrotum, the *intercolumnar fascia*, the *cremaster muscle* and cremasteric fascia, and the *infundibuliform fascia*, which is united to the cord by a layer of loose cellular tissue; lastly, the testicle has a special serous tunic, named the *tunica vaginalis*, which forms a closed sac, and covers the proper *fibrous coat* of the gland.

The *scrotum.*—The *scrotum* forms a purse-like investment for the testes and part of the spermatic cords. Its condition is liable to certain variations according to the state of the health and other circumstances: thus, it is short and corrugated in robust persons and under the effects of cold, but becomes loose and pendulous in persons of weak constitution, and under the relaxing influence of heat. Its surface is marked off into two lateral halves by a slight median ridge, named the *raphé*, extending forwards to the under side of the penis, and backwards along the perineum to the margin of the anus.

1. The *skin* in this situation is very thin, and is of a darker colour

* Ueber die organischen Nerven der erectilen männlichen Geschlechts-Organe, &c., 1836.

than elsewhere; it is generally thrown into rugæ or folds, which are more or less distinct according to the circumstances already mentioned. It is furnished with sebaceous follicles, the secretion from which has a peculiar odour, and it is covered over with thinly scattered crisp and flattened hairs, the bulbs of which are seen through the skin when the scrotum is extended. The superficial blood-vessels are also readily distinguished through this thin integument.

2. Immediately beneath the skin of the scrotum there is found a thin layer of a peculiar loose reddish tissue, endowed with contractility, and named the *dartos*. This subcutaneous layer is continuous with the *superficial fascia* of the groin, perineum, and inner side of the thighs, but acquires a different structure, and is perfectly free from fat. This dartoid tissue is more abundant on the fore part of the scrotum than behind, and, moreover, it forms two distinct sacs, which contain the corresponding testes, and are united together along the middle line so as to establish a median partition between the two glands, named the *septum scroti*, which is adherent below to the deep surface of the raphé and reaches upwards to the root of the penis. The dartos is very vascular, and consists of a loose areolar tissue containing reddish fasciculi, which have long been recognised as possessing peculiar physiological characters. The microscopical and chemical examination of the dartos did not, however, appear to justify the opinion that it contained muscular tissue, and, accordingly the slow contractions of the dartos were held to afford an example of non-muscular contractility; but, more recently, distinct muscular fibres, of the plain or unstriped variety, have been recognised in it (vol. i. p. 322). Its contractility, as just stated, is slow in its action; it is excited by the application of cold and of mechanical stimuli, but, apparently, not by electricity. By its action the testes are drawn up or sustained, and at the same time the skin of the scrotum is more or less corrugated.

The five succeeding layers or coverings are those which are derived from the parietes and lining membranes of the abdomen.

3. The *intercolumnar* or *spermatic* fascia is derived from the tendon of the external oblique muscle of the abdomen. On passing forward through the opening in that tendon, named the external abdominal ring, the spermatic cord receives a thin membranous investment, which is, as it were, continuous with the layer of so-called intercolumnar fibres passing obliquely across the upper border of that opening. This is the *intercolumnar* fascia. It is attached above to the margins of the external ring, and is prolonged downwards upon the cord and testicle. It lies at first beneath the superficial fascia, but lower down beneath the dartos, and it is intimately connected with the layer next in order.

4. The succeeding layer is composed of scattered bundles of muscular tissue, connected together into a continuous covering by intermediate cellular membrane. The red muscular portion, which is continuous with the lower border of the internal oblique muscle of the abdomen, constitutes the *cremaster* muscle, or *tunica erythroïdes*, and the entire covering is named the *cremasteric* fascia.

The *cremaster* muscle, so named because it serves to suspend the testicle (κρεμάω, to suspend), commences within the inguinal canal, immediately beneath the lower border of the internal oblique muscle, in the form of two bundles of muscular tissue, which cross obliquely over the front of the spermatic cord; lower down, the muscular fasciculi form a series of loops or slings with their concavities turned upwards, which descend upon the front and sides of the cord, and which, becoming in succession longer and longer, ultimately reach as low as the testicle. The scattered bundles of the cremaster muscle would seem to be derived from the internal oblique muscle, and sometimes, perhaps, from the transversalis also. The lowermost fibres of one or both muscles may be supposed to be carried forward by the testicle in its descent into the scrotum. The attachments of the cremaster certainly coincide with this idea of its formation. When carefully examined it is found to consist of an external and an internal portion, the separate bundles of which join to form the loops upon the spermatic cord already spoken of. The external and larger portion arises from the deep surface of Poupart's ligament, or rather from the outer end of the deep crural arch, immediately below the internal oblique muscle, and passing along the spermatic cord, through the external abdominal ring, descends upon it, rather on its outer side, and spreads out into bundles, differing in thickness and length in different subjects. The shorter bundles cross in loops over the cord, while the longest reach down towards the testicle, and are attached, directly or by means of tendinous fibres, to the outer surface of the tunica vaginalis. Most of the bundles then appear to be prolonged upwards on the inner side of the cord, to form the internal and smaller portion of the muscle, which enters the lower end of the inguinal canal, and is inserted by a small tendinous band into the spine and crest of the pubes, close to the insertion of the internal oblique muscle.

Sometimes the loops of the cremaster completely surround the cord, some lying behind it, but the larger number, being, as usual, in front. In these cases it would seem as if the testicles had passed through the fibres of the internal oblique, and not merely beneath them. Occasionally the muscular bundles can be traced only part of the way down the cord, the lower portion of the latter, as well as the testicle, being covered instead by a layer of firm cellular membrane, similar in appearance to that which connects the separate muscular bundles together, and containing some tendinous fibres.

The cremaster muscles not only aid in suspending the testes, but can raise them up towards the ring, and, perhaps at the same time, compress them in a slight degree. They are muscles with striped fibres, and in some persons are completely under voluntary command. Their action is sudden, and altogether distinct from that of the dartos.

In cases of old scrotal hernia, and also in hydrocele, the cremaster becomes very strongly developed. There is, of course, no such muscle in the female; but in that sex, an accidental muscle, analogous to it, may be produced upon an inguinal hernia in its descent beneath the margin of the internal oblique muscle.

5. The *infundibuliform fascia* and *cellular investment* of the cord.—

These are continuous above with the *fascia transversalis* and the sub-peritoneal cellular membrane. Immediately beneath the cremaster muscle and cremasteric fascia, and closely adherent to them, is a thin membranous layer, which loosely surrounds the spermatic cord. It may be traced above, commencing at the internal abdominal ring, in form of a funnel-shaped offset from the transversalis fascia, and is prolonged as a sheath upon the vas deferens and spermatic vessels, as these pass out of the abdomen. It then descends through the inguinal canal and scrotum upon the cord, investing it completely, and being connected below with the posterior part of the testicle and the outer surface of its serous tunic.

On forcing air beneath the infundibuliform fascia, a quantity of loose and delicate cellular tissue is seen to connect its internal or deep surface with the vas deferens and spermatic blood-vessels, and to form lamellæ between them. This areolar tissue is continuous above with the sub-serous cellular tissue found beneath the peritoneum on the anterior wall of the abdomen; below, it is lost upon the back of the testicle. Together with the infundibuliform fascia just described, it forms the *fascia propria* of Sir A. Cooper.

Lying amongst this loose cellular tissue, in front of the upper end of the cord, there is often seen a fibro-cellular band, which is connected above with the pouch of peritoneum found opposite the upper end of the inguinal canal, and reaches downwards for a longer or shorter distance along the spermatic cord. Occasionally it may be followed as a fine cord, down to the upper end of the tunica vaginalis; sometimes no trace of it whatever can be detected. It is the vestige of a tubular process of the peritoneum, which once connected the tunica vaginalis with the general peritoneal membrane. The testes of the fœtus are placed in the abdomen behind the peritoneum. When they are about to escape from the abdominal cavity, a pouch of the lining membrane extends itself in advance of each testicle along the corresponding inguinal canal towards the scrotum. Into this pouch, or *processus vaginalis peritonæi*, as it is named, the testicle projects from behind, supported by a duplicature of the serous membrane, named the *mesorchium*. Sooner or later after the gland has reached the scrotum the upper part or neck of this pouch becomes obliterated, from the internal abdominal ring near to the upper part of the testicle, leaving no trace but the indistinct fibrous cord already described, whilst the lower part remains as a closed serous sac, into which the testicle depends, and which is henceforth named the tunica vaginalis. Sometimes the tube of peritoneum becomes closed at intervals only, leaving a series of sacculi along the front of the cord; or a long pouch may continue open at the upper end, leading from the abdominal cavity into the inguinal canal. Lastly, in some instances, the peritoneal process remains altogether pervious, and the cavity of the tunica vaginalis is continuous with that of the peritoneum. In such a case of congenital defect, a portion of intestine or omentum may descend from the abdomen into the inguinal canal and scrotum, and constitute what is named a congenital hernia.

In the female, an analogous pouch of peritoneum descends in the

fœtus, for a short distance along the round ligament of the uterus, and has received the appellation of the *canal of Nuck.* Traces of it may almost always be seen in the adult.

6. The *tunica vaginalis.*—Beneath the parts already described, which form investments common to the cord and testis, is the proper serous covering of the latter, named the *tunica vaginalis.* The mode in which this coat is derived from the peritoneum has just been explained. In its completed condition it forms a shut sac, the opposite walls of which are in contact with each other. Like the serous membranes in general, of which it affords one of the simplest examples, it may be described as consisting of a *visceral* and a *parietal* portion. The former closely invests the greater part of the body of the testis (fig. 485,[2]), as well as the epididymis ([3], [4]), between which parts it recedes in form of a pouch, and lines their contiguous surfaces, and it adheres intimately to the proper fibrous tunic of the gland; hence it is named *tunica vaginalis testis.* Along the posterior border of the gland, where the vessels and ducts enter or pass out, the serous coat is wanting, being reflected thence so as to become continuous with the *parietal* or scrotal portion ([5]), which completes the sac, and forms a smooth lining membrane to the lower part of the other investments of the testicle, viz., the infundibuliform fascia, the cremaster, and the spermatic fascia, which are there blended together and connected with the external surface of the tunica vaginalis.

Fig. 485.

The testicle, and part of the spermatic cord, with the tunica vaginalis laid open.—1. Lower part of the spermatic cord. 2. Body of the testicle. 3, 4. The epididymis. 3. Globus major or head. 4. Globus minor or tail. 5. Internal surface of scrotal portion of tunica vaginalis.

The parietal or scrotal portion of the tunica vaginalis is more extensive than that which covers the body of the testis; it reaches upwards, sometimes for a considerable distance, upon the spermatic cord, extending somewhat higher on the inner than on the outer side. It also reaches downwards below the testicle, which, therefore, appears to be suspended at the back of the serous sac, when this latter is distended with fluid.

The internal surface of the tunica vaginalis is free, smooth, epitheliated, and moistened with a small quantity of an albuminous fluid. The epithelium is squamous.

VESSELS AND NERVES OF THE COVERINGS OF THE TESTIS AND CORD.

The *arteries* are derived from several sources. Thus, the two external pudic arteries (vol. i. p. 623), branches of the femoral, reach the front and sides of the scrotum, supplying the integument and dartos; the superficial perineal branch of the internal pudic artery (p. 615) is distributed to the back part of the scrotum; and, lastly, more deeply seated than either of these, is a branch given from the epigastric

artery, named cremasteric (p. 620), because it is chiefly distributed to the cremaster muscle, but it also supplies small branches to the other coverings of the cord, and its ultimate divisions anastomose with those of the other vessels. The *veins*, which, owing to the thinness of the integuments, are apparent on the surface of the scrotum, follow the course of the arteries. The *lymphatics* pass into the inguinal lymphatic glands.

The *nerves* also proceed from various sources. Thus, the ilio-inguinal, a branch of the lumbar plexus (vol. ii. p. 322), comes forwards through the external abdominal ring, and supplies the integuments of the scrotum; this nerve is joined also by a filament from the ilio-hypogastric branch of the same plexus: sometimes two separate cutaneous nerves come forward through the external ring. The two superficial perineal branches of the internal pudic nerve (p. 331) accompany the artery of the same nerve and supply the inferior and lateral parts of the scrotum. The inferior pudendal, a branch of the small sciatic nerve (p. 332) joins with the perineal nerves, and is distributed to the sides and fore part of the scrotum. Lastly, a deeper nerve, springing from the lumbar plexus, and named genito-crural (p. 323), comes into contact with the spermatic cord at the internal abdominal ring, passes with it through the inguinal canal, and supplies the fibres of the cremaster, besides sending a few filaments to the other deep coverings of the cord and testicle.

THE TESTES.

The *testes* are suspended in the scrotum at unequal heights, that of the left side being usually lower than the other. They are of an oval form, but are slightly compressed laterally, so that they have two somewhat flattened sides or faces, an upper and a lower end, an anterior and a posterior border. They are from an inch and a half to two inches long, about an inch and a quarter from the anterior to the posterior border, and nearly an inch from side to side. The weight of each varies from three quarters of an ounce to an ounce, and the left is often a little the larger of the two.

Both sides of the testicle, the upper and the lower end, and the anterior border, which is rounded, are free, smooth, and closely invested by the tunica vaginalis. The posterior border, however, which is also called the straight border, is attached to the spermatic cord, and it is here that the vessels and nerves enter or pass out. When the testis is suspended in its usual position, its upper end is directed obliquely forwards and outwards, as well as upwards, whilst the lower, which is rather smaller, has the opposite direction. It follows from this that the posterior or attached border is turned a little upwards, and the outer flattened face slightly backwards.

Along the outer edge of the posterior border of the gland, and resting also on the neighbouring portion of its outer face, is placed a long narrow appendage, named from its position the *epididymis* (ἐπὶ and δίδυμος, testis). This body is curved so as to be adapted to the testicle. Its upper extremity, which is enlarged and obtuse, is named the *head* of the epididymis, or *globus major* (³); the lower, which is more

pointed, is termed the *tail*, or *globus minor* (4); whilst the intervening and narrower portion is named the *body*. The outer convex surface of the epididymis and the thin anterior border are free, and covered by the tunica vaginalis. The inner surface, except at the upper and lower ends, is also free, and invested by the same tunic, which here forms a pouch between the epididymis and the outer face of the testicle, and nearly surrounds the epididymis, except along its posterior border, which is held to the gland by a duplicature of the serous membrane. At its upper and lower extremity the inner surface of the epididymis is attached to the testicle,—the lower end, or globus minor, by fibrous tissue and a reflection of the tunica vaginalis, the globus major by the efferent ducts of the testicle also. Lastly, the long posterior border of this appendage is connected with the spermatic cord by numerous blood-vessels, supported by dense cellular tissue.

The epididymis contains a part of the excretory apparatus of the testicle, and is principally composed of the convolutions of a long tortuous canal or efferent duct, which will be presently described.

Upon the head of the epididymis there is very commonly found a small soft pendulous body of a reddish colour, about two or three lines in length. Its presence was first pointed out by Morgagni, but its nature is not known.

Structure of the testis.—Besides the numerous coverings already noticed, the testis is enclosed in a proper coat, named the *tunica albuginea* (fig. 486,2). This is a dense unyielding fibrous membrane, of a bluish-white colour, and about half a line thick, which immediately invests the soft substance of the testicle, and preserves the form of the gland. It is composed of bundles of fibrous tissue, which interlace in every direction. The outer surface is for the most part covered by the tunica vaginalis, except along the posterior border of the testicle, where the spermatic vessels pass through, and except also at the parts to which the two extremities of the epididymis are attached. From the upper end of the testicle, opposite the globus major, the tunica albuginea is continuous with thin prolongations of fibrous tissue which invest the epididymis, support and hold together the numerous convolutions of its tortuous canal, and are ultimately continued upon the vas deferens.

At the posterior and upper border of the testis, the fibrous tissue of the tunica albuginea is prolonged forwards for a few lines into the substance of the gland, so as to form within it an incomplete vertical septum, known as the *corpus Highmorianum*, and named by Sir A. Cooper *mediastinum testis* (3). Projecting inwards from the back of the testis, it extends from the upper nearly to the lower end of the gland, and it is wider above than below. The firm tissue of which it is composed is traversed by a network of seminal ducts, and by the larger blood-vessels of the gland, which are lodged in channels formed in the fibrous tissue.

From the front and sides of the corpus Highmorianum numerous slender fibrous cords of various lengths are given off in all directions, and are attached by their other ends to the internal surface of the

tunica albuginea at different points, so as to assist in maintaining the general shape of the testicle. Other offsets from the mediastinum, consisting of delicate membranous laminæ, meet with similar ones

[Fig. 486.

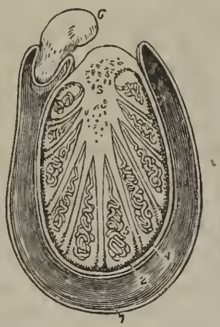


Fig. 487.

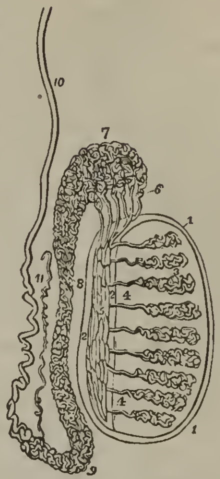


Fig. 486. A transverse section of the testicle. 1. The cavity of the tunica vaginalis. 2. The tunica albuginea. 3. Corpus highmorianum or mediastinum testis. 4. Tunica vasculosa of the testis. 5. Glandular substance of the testicle. 6. A section of the epididymis.

Fig. 487. A plan of a vertical section of the testicle, to show the mode of arrangement of the ducts. 1, 1. Tunica albuginea. 2, 2. Corpus highmorianum. 3, 3. Tubuli seminiferi convoluted into lobules. 4. Vasa recta. 5. Rete vasculosum testis. 6. Vasa efferentia. 7. Coni vasculosi constituting the globus major of the epididymis. 8. Body of the epididymis. 9. Its globus minor. 10. Vas deferens. 11. Vasculum aberrans or blind duct.—S. & H.]

from the tunica albuginea, and enclose the several lobes into which the substance of the testis is divided. The whole internal surface of the tunica albuginea is covered by a multitude of fine blood-vessels, which are branches of the spermatic artery and veins, and are held together by a delicate cellular web. Similar delicate ramifications of vessels are seen on the various fibrous offsets of the mediastinum, upon which the blood-vessels are thus supported in the interior of the gland. This vascular network, together with its connecting cellular tissue, constitutes the *tunica vasculosa* (4) of Sir A. Cooper.

The proper *glandular substance* of the testicle (5) is a soft pulpy mass of a reddish-yellow colour, which is divided into numerous small lobes, contained in the separate compartments formed by the fibro-vascular expansions which extend between the corpus Highmorianum and the internal surface of the tunica albuginea (see the illustrative plan, fig. 487). The number of these *lobes* (lobuli testis) has been estimated at 250 by Berres, and upwards of 400 by Krause. Their shape is somewhat conical or pyriform, the larger end of each being turned towards the surface of the testicle, and the smaller one towards the mediastinum. They differ in size according to their position, those which occupy the middle of the gland and reach its anterior border being longer and larger than the rest. The substance of these lobes

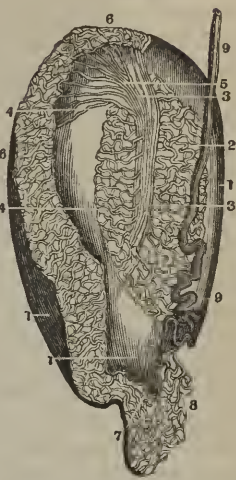
consists almost entirely of minute convoluted tubes (3), named *tubuli seminiferi, vascula serpentina*, in the interior of which the seminal fluid is secreted. Each lobe contains one, two, three, or even more of these convoluted tubules, the coils of which, being but loosely held together, may be more or less successfully unravelled by careful dissection under water. According to Monro, their total number is about 300, and the length of each tubule about sixteen feet; but Lauth estimates their mean number to be 840, and the average length of each to be not more than two feet and a quarter. Their diameter, which is uniform through their whole course, is from $\frac{1}{200}$th to $\frac{1}{150}$th of an inch. The capillary vessels are distributed in form of a network upon the outer surface of the tubules, supplying them with blood, and constituting, together with fine bundles of cellular tissue in very sparing quantity, a slender bond of union between them; this feeble connexion between the tubuli renders necessary their inclosure and support by a dense fibrous capsule. As compared with the ultimate ducts of glands generally, the coats of the tubuli seminiferi are strong, and hence, notwithstanding their comparatively loose aggregation, they may, as well as the system of ducts into which they ultimately unite, be injected with mercury. They are lined with an epithelium, composed of nucleated granular corpuscles. The mode in which they commence, as far as at present known, appears to be twofold, for they have been seen commencing near the surface of the lobes by free closed extremities, but more frequently by anastomotic arches or loops. They also anastomose together occasionally in their course, and the tubuli of adjacent lobes are often found communicating with one another. After an exceedingly tortuous or serpentine course from side to side of the lobe to which they belong, they at length, in approaching the corpus Highmorianum, lose in a great measure the convoluted disposition, becoming at first slightly flexuous and then nearly straight. The separate tubuli of each lobe, and then those of adjoining lobes, unite together into larger tubes, which pass through the fibrous tissue of the mediastinum and amongst the branches of the blood-vessels, and form the next order of the seminal ducts.

These, which, from their comparatively straight course, are named *tubuli recti* or *vasa recta* (4), are upwards of twenty in number, and are fom $\frac{1}{90}$th to $\frac{1}{70}$th of an inch in diameter. They pass upwards and backwards through the fibrous tissue, as already stated, and end in a close network of tubes, named by Haller the *rete vasculosum testis* (figs. 487,[5] 488,[3]), which lies in the substance of the corpus Highmorianum, along the back part of the testicle, but in front of the primary subdivisions of the spermatic blood-vessels before these enter the gland. The tubes composing the rete have very thin walls.

All the seminal ducts hitherto mentioned, namely, the tubuli seminiferi, tubuli recti, and rete testis, are included within the proper fibrous coat of the testicle, and form in great part the substance of the gland; but the succeeding order of ducts transmit the seminal fluid from the testis to the epididymis, and are named accordingly *vasa efferentia* (5). These are from twelve to fifteen, or sometimes twenty in number; they perforate the tunica albuginea at the upper end of the pos-

terior border of the testicle, opposite to the globus major of the epididymis, of which they may be said to form a part, and in the convoluted canal of which they ultimately terminate. On emerging from the testis, these vasa efferentia are straight, but, becoming more and more convoluted, as they proceed towards the epididymis, they form a series of small conical masses, the bases of which are turned in the same direction, and which are named *coni vasculosi* (fig. 487,[7] fig. 488,[6]). The largest of these cones is about eight lines long, and, when unrolled, each is found to consist of a single coiled duct, varying from six to eight inches in length, and the diameter of which gradually decreases from the testis to the epididymis (Huschke). Opposite to the globus major these separate efferent vessels open, at intervals of about three inches, into a single canal or duct, the intervening and subsequent convolutions of which constitute the epididymis itself.

[Fig. 488.



The testicle injected with mercury.—1. Tunica albuginea. 2. Seminiferous tubes. 3. The rete vasculosum testis. 4. A globule of mercury which has ruptured the tubes. 5. The vasa efferentia which form the coni vasculosi. 6. Coni vasculosi forming the head of the epididymis. 7. Epididymis. 8. Globus minor of the epididymis. 9. Vas deferens.—S. & H.]

The *canal of the epididymis* (fig. 487,[8] 488,[7]) is disposed in innumerable coils, and extends from the globus major downwards to the globus minor or tail, where, turning upwards, it is continued on as the vas deferens. Its flexuosities are exceedingly numerous, so that when unrolled it is found to be twenty feet and upwards in length. The smallest windings are supported and held together by fine cellular tissue; but, besides this, numerous fibrous partitions are interposed between larger masses of the coils, which have been named the *lobes* of the epididymis, the general direction of which is across that body. The canal of the epididymis is, at its commencement, about $\frac{1}{70}$th of an inch in diameter, but it goes on diminishing, till, towards the globus minor, it is about $\frac{1}{90}$th of an inch, after which it again increases in size, and becomes less tortuous as it approaches the vas deferens. Its coats, which are at first very thin, become thicker as it proceeds.

VAS DEFERENS.

The *vas deferens*, or excretory duct of the testis ([9]), is a hard round tube, which forms the continuation upwards of the convoluted canal of the epididymis. It commences at the lower end of that appendage, or the globus minor, and, being at first rather tortuous, but afterwards becoming straight, it ascends upon the inner side of the epididymis, and along the back of the testicle, separated from both, however, by the blood-vessels passing to or from the gland. Continuing, then, to ascend in the spermatic cord, the vas deferens accompanies the spermatic artery, veins, and nerves, as far as the internal abdominal ring.

Between the testicle and the external ring its course is vertical; it lies behind the spermatic vessels, and is readily distinguished by its hard cord-like feel. Having passed obliquely upwards and outwards along the inguinal canal, and reached the inner border of the internal abdominal ring, it leaves the spermatic vessels (which extend to the lumbar region), and turns suddenly downwards and inwards into the pelvis, crossing over the external iliac vessels, and turning round the outer or iliac side of the epigastric artery. Running beneath the peritoneum, it reaches the side of the bladder (fig. 478, *i*), on which it curves backwards and downwards to the under surface of that viscus, and then runs forwards to the base of the prostate gland. In its course within the pelvis, the vas deferens gradually approaches nearer to the middle line; it crosses over and to the outer side of the cord of the obliterated hypogastric artery, and to the inner side of the ureter. Beyond this point, where the vas deferens reaches the base of the bladder, it ceases to be covered by the peritoneum, and is found attached to the coats of the bladder, lying between that viscus and the rectum. In this situation (fig. 479,[7],[8]) it runs forwards, and at the same time inwards, so as gradually to approach its fellow of the opposite side. Upon the base of the bladder, the two vasa deferentia are situated between two membranous receptacles for the semen, named the seminal vesicles ([9], [11]); and close to the base of the prostate ([3]), each vas deferens ends by joining with the duct from the corresponding seminal vesicle, which is placed on its outer side, to form one of the two common seminal or ejaculatory ducts ([10]).

The vas deferens, therefore, pursues a long and somewhat complicated course, from its commencement at the lower end of the epididymis to its termination at the base of the prostate, beneath the bladder. It measures nearly two feet in length. In the greater part of its extent it is cylindrical or slightly compressed, and has an average diameter of about one line and a quarter; but towards its termination, beneath the bladder, it becomes enlarged and sacculated, approaching thus in character to the seminal vesicle. Previous to its junction with the duct of that vesicle, it again becomes narrowed to a fine cylindrical canal. The walls of the vas deferens are very dense and strong, measuring one-third of a line in thickness; whilst, on the other hand, the canal is proportionably fine, its area being only from one-fourth to one-half a line across. In the sacculated portion the passage is much wider, and the walls are thinner in proportion.

Besides an external cellular investment, and an internal lining mucous membrane, the vas deferens is provided with an intermediate tunic, which is thick, dense in structure, somewhat elastic, and of a deep yellowish colour. This coat consists principally of longitudinal fibres, mixed with some circular ones. Huschké describes two longitudinal layers with intermediate circular fibres. These fibres are most probably of a muscular nature. The vasa deferentia of the dog, cat, and rabbit were found by E. Weber to exhibit lively peristaltic contractions when stimulated by means of electricity.

The surface of the mucous membrane is pale; it is thrown into three

or four fine longitudinal ridges, and, besides this, in the sacculated portion of the duct, is marked by numerous finer rugæ which enclose irregular polyhedral spaces, resembling in this the lining membrane of the vesiculæ seminales. The epithelium is of the columnar kind.

Vas aberrans (fig. 487,[11]).—This name was applied by Haller to a long narrow tube, or diverticulum, discovered by him and since very frequently met with, which leads off from the lower part of the canal of the epididymis, or from the commencement of the vas deferens, and extends upwards in a tortuous manner for two or three inches, amongst the vessels of the spermatic cord, where it ends by a closed extremity. Its length, when it is unravelled, ranges from one inch and a half to as much as fourteen inches; and its breadth increases towards its blind extremity. Sometimes this diverticulum is branched, and occasionally there is more than one such aberrant duct. Its structure appears to be similar to that of the vas deferens, but its office is unknown.

THE SEMINAL VESICLES AND EJACULATORY DUCTS.

The *seminal vesicles* (vesiculæ seminales; fig. 479,[9],[11]) are two membranous receptacles, situated, one on each side, upon the base of the bladder, between it and the rectum. When distended they form two oblong sacculated bodies, somewhat flattened above but convex below, widened behind and narrow in front. Their length is usually about two inches and a half, and their greatest breadth from four to six lines; but they vary in size in different individuals, and also on opposite sides of the same subject.

Their upper surface is firmly attached to the coats of the bladder, on the under surface of which they extend forwards and inwards from near the terminations of the two ureters to the base of the prostate gland. The posterior obtuse extremities of the two vesiculæ seminales are separated widely from each other, but anteriorly they converge so as to approach the two vasa deferentia, which run forwards to the prostate between them. The small triangular portion of the base of the bladder, which is marked off by the two vesiculæ seminales at the sides, and behind by the line of reflection of the peritoneum from the rectum to the bladder, rests immediately on that intestine, at least there is nothing interposed but the vasa deferentia. The seminal vesicles themselves are also supported by the sides of the rectum, but they are separated from the bowel by a layer of the recto-vesical fascia, which holds them to the base of the bladder.

The sacculated appearance of the vesiculæ seminales is owing to their peculiar formation. Each consists of a tube coiled on itself in a complicated manner, and firmly held in that condition by a very dense fibrous tissue. When unrolled (see fig. 479), this tube is found to be from four to six inches long, and about the width of a quill. Its posterior extremity is closed, so that it forms a long cul-de-sac; but there are generally, if not always, several longer or shorter branches or diverticula developed from it, which also end by closed extremities. Its anterior extremity, which forms the fore part of the vesicula, becomes straight and narrowed, and ends opposite the base of the prostate by uniting on its inner side, at a very acute angle, with the

narrow termination of the corresponding vas deferens to form a single canal, which is the common seminal or ejaculatory duct.

In structure, the vesiculæ seminales resemble very closely the adjoining sacculated portions of the vasa deferentia. Besides an external fibro-cellular investment, connected with the recto-vesical fascia, they have a proper coat, which is firm, dense, and somewhat elastic, and consists of rigid white fibres, and of others of a deep yellowish-brown hue. In some animals muscular fibres have been shown in the coats of the seminal vesicles, and, according to E. H. Weber, they exist in the human subject also. The mucous membrane is pale, or has a dirty brownish-white colour. It is traversed by multitudes of fine rugæ, which form an areolar structure resembling that seen in the gall-bladder, but composed of much finer meshes: this areolar character, as already stated, begins to appear in the lower sacculated part of the vas deferens, and is considered by Weber as constituting a species of glandular structure. The epithelium of the vesiculæ is of the squamous kind: its particles have a granular character.

The seminal vesicles serve as receptacles or reservoirs for the semen, as is easily proved by a microscopic examination of their contents; but, besides this, it is supposed by some that they secrete a peculiar fluid which is incorporated with the semen.

The *common seminal* ducts, or *ejaculatory* ducts (fig. 479,[10]), two in number, are formed on each side by the junction of the narrowed extremities of the corresponding vas deferens and vesicula seminalis, close to the base of the prostate gland. From this point they run forwards and upwards, at the same time approaching each other, and then pass side by side through the prostate between its middle and two lateral lobes. After a course of nearly an inch, during which they become gradually narrower, they end in the floor of the prostatic portion of the urethra by two slit-like orifices, placed one on each prominent margin of the longitudinal depression which exists at the anterior part of the verumontanum, named the sinus pocularis, or utriculus virilis. For a short distance the ejaculatory ducts run in the substance of the walls of this sinus. (See p. 535.)

The coats of the common seminal duct, as compared with those of the vas deferens and vesicula, are very thin. The strong outer tunic almost entirely disappears after the entrance of the ducts between the lobes of the prostate; and the mucous membrane becomes gradually smoother, and at length passes into that of the urethra.

It is along these ejaculatory ducts that the fluid contained in the seminal vesicles and vas deferens is forced into the urethra.

VESSELS AND NERVES OF THE TESTIS.

The testicle and its excretory apparatus receive blood-vessels and nerves from different sources from those which supply the coverings of those parts.

The *spermatic artery*, or proper artery of the testicle (vol. i. p. 602), is a slender and remarkably long branch, which arises from the abdominal aorta, and reaching the spermatic cord, descends along it to the gland.

In early fœtal life its course is much shorter, as the testis is then situated near the part of the aorta from which the artery arises. As the vessel approaches the testicle, it gives off small branches to the epididymis, and then divides into others which perforate the tunica albuginea at the back of the gland, and pass through the corpus Highmorianum; some spread out on the internal surface of the tunica albuginea, whilst others run along between the lobes of the testis, supported by the fibrous processes of the mediastinum. The smallest branches ramify on the delicate membranous septa between the lobes, before supplying the seminiferous tubes.

The vas deferens receives from the superior vesical artery a long slender branch, which accompanies the duct, and is hence named the *deferent artery*, or *artery of the vas deferens* (p. 610). It ramifies on the coats of the duct, and reaches as far as the testis, where it anastomoses with the spermatic artery.

The *spermatic veins* (vol. ii. p. 29,) commence in the testis and epididymis, pass out at the posterior border of both, and unite into larger vessels, which freely communicate with each other as they ascend along the cord, and form a plexus, named the *pampiniform plexus.* Ultimately two or three veins follow the course of the spermatic artery into the abdomen, where they unite into a single trunk, that of the right side opening into the vena cava, and that of the left into the left renal vein.

The *lymphatics* (p. 51) accompany the spermatic vessels and terminate in the lumbar lymphatic glands, which lie about the large blood-vessels in front of the vertebral column.

The *nerves* are derived from the sympathetic system. The spermatic plexus (p. 351) is a very delicate set of nervous filaments, which descend upon the spermatic artery from the aortic plexus. Some additional filaments, which are very minute, come from the hypogastric plexus, and accompany the artery of the vas deferens.

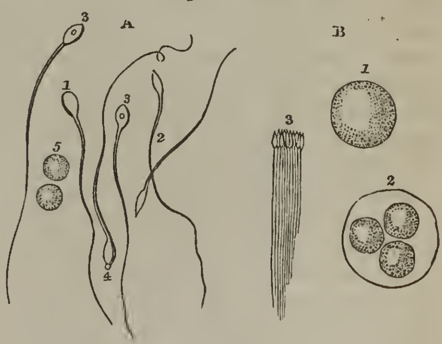
The vesiculæ seminales receive branches from the inferior vesical and middle hæmorrhoidal arteries. The veins and lymphatics correspond. The nerves belong to the sympathetic system, and come from the hypogastric plexus.

The *semen* is a thick whitish fluid, which consists of a liquor seminis, and of certain solid particles.

The *liquor seminis* is colourless, transparent, and of an albuminous nature. It contains floating in it, besides squamous and columnar epithelium cells, oil-like globules and minute granular matter, two principal microscopic constituents, named the *seminal granules* (Wagner), and the *seminal animalcules*, *spermatozoa* or spermatic filaments.

The *seminal granules* (fig. 489,[5]) are rounded colourless corpus-

Fig. 489.



Spermatozoa from man, and their development. (Wagner).—A. Spermatozoa from the semen of the vas deferens. 1 to 4. Show their variety of character. 5. Seminal granules —B. Contents of the semen of the testis. 1. Large round corpuscle or cell. 2. A cell containing three roundish granular bodies, from which the spermatozoa are developed. 3. A fasciculus of spermatozoa, as they are seen grouped together in the testis.

cles, having a granular aspect. They average about $\frac{1}{4000}$th of an inch in diameter, and may be allied to mucous corpuscles.

The *spermatozoa* (fig. 489, A,) are peculiar particles, endowed with a power of executing a brisk lashing movement. Each consists of a flattened oval part or so-called body, and of a long filiform tail. The body is about $\frac{1}{8000}$th of an inch in width, and the entire spermatozoon is from $\frac{1}{500}$th to $\frac{1}{400}$th of an inch in length. The body often contains a spot, and, at its junction with the narrow part or tail, there is frequently a slight projecting fringe or collar. The spermatozoa are developed in the interior of nucleated cells, which become enlarged into transparent vesicular bodies of considerable size (B).

ORGANS OF GENERATION IN THE FEMALE.

The generative organs in the female consist of the *ovaries*, *uterus*, and *Fallopian tubes*, which are named the *internal*, and the *vagina* and *vulva*, named the *external* organs of generation.

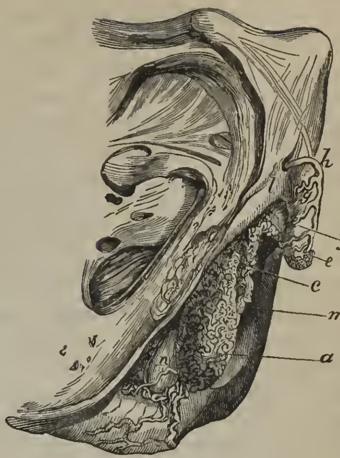
The *vulva*, or *pudendum*, is a general term, which includes all the parts perceptible externally, viz., the mons Veneris, the labia, the hymen or carunculæ, the clitoris, and the nymphæ. The orifice of the urethra also requires to be noticed in connexion with these parts.

The integument on the fore part of the pubic symphysis is elevated by a quantity of cellular and adipose substance deposited beneath it, and is covered with hair. This part surmounts the labia, and has been called *mons Veneris*. The *labia pudendi* (labia externa v. majora) extend downwards and backwards from the mons, gradually becoming thinner as they descend. They form two rounded folds of integument so placed as to leave an elliptic interval (*rima*) between them, the outer surface of each being continuous with the skin, and covered with scattered hairs, whilst the inner is lined by the commencement of the genito-urinary mucous membrane. Between the skin and mucous membrane there is found, besides fat, vessels, nerves, and glands, some tissue resembling that of the dartos in the scrotum of the male. The labia majora unite beneath the mons and also in front of the perineum, the two points of union being called commissures. The posterior or inferior one is about an inch distant from the margin of the anus, the interval between them being named the perineum. Immediately within the posterior commissure, the labia are connected by a slight transverse fold (*frænulum pudendi*) which has also received the name of *fourchette*, and is commonly torn in the first parturition. The space between it and the commissure has been called *fossa navicularis*.

Beneath the anterior commissure, and concealed between the labia, is the *clitoris* (fig. 490 *f*), a small elongated body analogous in conformation and structure to a diminutive penis, though differing in not being perforated by the canal of the urethra, and also in not having the corpus spongiosum attached along beneath it. It consists of two *corpora cavernosa*, which are attached by *crura* (*l*) to the rami of the ischium and pubes, and are united together by their flattened inner surfaces, which form an incomplete pectiniform septum. The body of the clitoris, which is very short and hidden beneath the mucous membrane, is surmounted by a small *glans* (*e*), consisting of spongy erectile tissue. The glans is imperforate, but highly sensitive, and covered

with a membranous fold, analogous to the prepuce. There is a small suspensory ligament (fig. 491), like that of the penis; and the two ischio-cavernous muscles, here named *erectores clitoridis*, have the same connexions as in the male, being inserted into the crura of the corpora cavernosa.

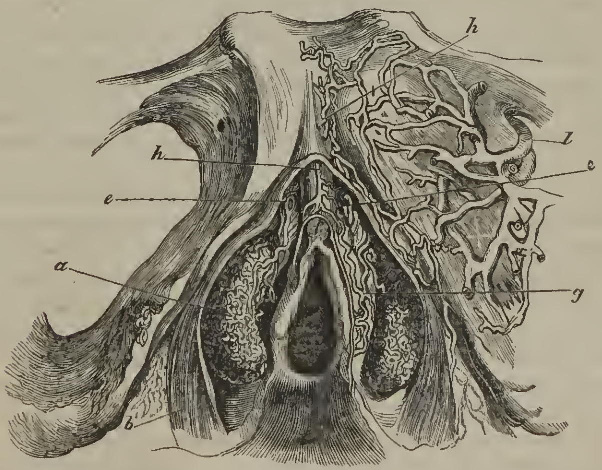
Fig. 490.



Lateral view of the erectile structures of the external organs of generation in the female, the skin and mucous membrane being removed (Kobelt).—*a*. Bulbus vestibuli. *c*. Plexus of veins named pars intermedia. *e*. Glans of the clitoris. *f*. Body of the clitoris. *h*. Dorsal vein. *l*. Right crus of clitoris. *m*. Vulva. *n*. Right gland of Bartholine.

From the glans and preputial covering of the clitoris two narrow folds of mucous membrane, in form not unlike a cock's comb, descend obliquely outwards for about an inch and a half, one on each side of the entrance of the vagina. These are the *nymphæ* (labia interna v. minora). Their inner surface is continuous with that of the vagina; the external insensibly passes into that of the labia majora. They contain vessels (fig. 491, *g*) between the laminæ of tegumentary membrane, but, according to Kobelt, no erectile plexus; indeed they would seem to correspond to the cutaneous covering of the male urethra (supposed to be split open), whilst the erectile structure corresponding to the bulb and spongy body (supposed to be in two halves) lies deeper, as will be presently explained.

Fig. 491.



Front view of the erectile structures of the external organs of generation in the female.—*a*. Bulbus vestibuli. *b*. Sphincter vaginæ muscle. *e, e*. Venous plexus, or pars intermedia. *f*. Glans of the clitoris. *g*. Connecting veins. *h*. Dorsal vein of the clitoris. *k*. Veins going beneath pubes. *l*. The obturator vein.

Between the nymphæ, is the angular interval called the *vestibule*, in which is situated the circular *orifice* of the *urethra*, or *meatus urinarius*, about an inch below the clitoris and just above the entrance to the vagina. The membrane which surrounds this orifice is rather prominent in most instances, so as readily to indicate its situation. The urethra itself has been already described (see p. 524).

Immediately below the orifice of the urethra is the *entrance* to the *vagina*, which, in the virgin, is usually more or less narrowed by the *hymen*. This is a thin duplicature of the mucous membrane, placed at the lateral and inferior parts of the entrance of the vagina; its form varies very considerably in different persons, but is most frequently semilunar, the concave margin being turned obliquely upwards or towards the pubes. Sometimes it is circular and is perforated only by a small round orifice, placed usually a little above the centre; and occasionally it is cribriform, or pierced with several small apertures; and it may completely close the vagina, constituting imperforate hymen. On the other hand, it is often reduced to a mere fringe, or it may be entirely absent. After its rupture, some small rounded elevations remain, called *carunculæ myrtiformes*.

The *mucous membrane* may be traced inwards from the borders of the labia majora, where it is continuous with the skin: it forms a fold over the vascular tissue of the nymphæ, and is then prolonged into the urethra and vagina. It is smooth, reddish in colour, is covered by a scaly epithelium, and is provided with a considerable number of mucous crypts and follicles, and with glands which secrete an unctuous and odorous substance. The mucous crypts and follicles are especially distinct on the inner surface of the nymphæ, and near the orifice of the urethra. The sebaceous glands are found beneath the prepuce, and upon the labia majora and outer surface of the nymphæ.

The *glands of Bartholine* (fig. 490, *n*) analogous to Cowper's glands in the male, are two reddish-yellow round or oval bodies, about the size of a large pea or small bean, lodged one on each side of the commencement of the vagina, between it and the erectores clitoridis muscles, beneath the superficial perineal fascia, and in front of the transverse muscles. Their ducts, which are long and single, run forward and open on the inner aspect of the nymphæ, outside the hymen or carunculæ myrtiformes.

Erectile tissue.—All the parts of the vulva are supplied abundantly with blood-vessels, and in certain situations there are masses composed of venous plexuses, or erectile tissue, which are analogous to those found in the male. The corpora cavernosa and glans clitoridis have already been described. Besides these there are two large leech-shaped masses (figs. 490, 491, *a*) about an inch long, consisting of a network of veins, enclosed in a fibrous membrane, and lying one on each side of the vestibule, a little behind the nymphæ. They are rather pointed at their upper extremities, and rounded below; they are suspended, as it were, to the crura of the clitoris and the rami of the pubes, covered internally by the mucous membrane, and embraced on the outer side by the fibres of the constrictor vaginæ muscle (fig. 491, *b*). These two plexiform masses were known to many of the older anatomists,

but have been more recently noticed by Taylor and Guthrie, and particularly described and figured by Kobelt. They are named by the latter *bulbi vestibuli*, (plexûs retiformes, De Graaf; crura clitoridis interna, Swammerdam; corpora cavernosa, Santorini; semi-bulbs, Taylor,) and are considered by that observer to be analogous to the bulb of the urethra in the male, which it will be remembered presents traces of a median division. In front of the bipartite bulb of the vestibule, is a smaller plexus on each side (fig. 490, *c*, fig. 491, *e e*), the vessels of which are directly continuous with those of the bulbus vestibuli behind, and of the glans clitoridis before. This is the *pars intermedia* of Kobelt, and is regarded by him as the analogue of the part of the male corpus spongiosum urethræ which succeeds the bulb: it receives large veins coming direct from the nymphæ.

Vessels.—The outermost parts of the vulva are supplied by the superficial pudendal arteries; the deeper parts and all the erectile tissues receive branches from the internal pudic arteries, as in the male. The veins also in a great measure correspond: there is a vena dorsalis clitoridis (*h*), receiving branches from the glans and other parts as in the male; the veins of the bulbus vestibuli pass backwards into the vaginal plexuses, and communicate also with the obturator veins (*l*); above, they communicate with the veins of the pars intermedia, those of the corpora cavernosa and of the glans of the clitoris, and also with the vena dorsalis. The lymphatics accompany the blood-vessels.

Nerves.—Besides sympathetic branches, which descend along the arteries, especially for the erectile tissues, there are other nerves proceeding from the lumbar and sacral plexuses; those from the former being the branches of the genito-crural (p. 323), and those from the latter, of the inferior pudendal and internal pudic nerves (p. 331), which last sends comparatively large branches to the clitoris.

THE VAGINA.

The *vagina* is a membranous and dilatable tube, extending from the vulva to the uterus, the neck of which is embraced by it. It rests below and behind on the rectum, supports the bladder and urethra in front, and is enclosed between the levatores ani muscles at the sides. Its direction is oblique from below upwards and backwards, in which course it is also slightly curved, the concavity of the curve being turned upwards and forwards. The axis of the vagina corresponds, therefore, first, with that of the outlet of the pelvis, and higher up with that of the pelvic cavity. In consequence of being thus curved, its length will be found greater if measured along the lower than along the upper wall, being in the latter situation about four inches, while in the former it amounts to five or six. Each end of the vagina is somewhat narrower than the middle part: the lower, which is continuous with the vulva, is the narrowest part, and has its long diameter from before backwards; the middle part is the widest from side to side, being flattened from before backwards, so that its anterior and posterior walls are ordinarily in contact with each other; at its upper end it is rounded, and expands to receive the vaginal portion of the

neck of the uterus, which is embraced by it at some distance from the os uteri. The vagina reaches higher up on the cervix uteri behind than in front, so that the uterus appears, as it were, to be let into its anterior wall.

On the *inner surface* of the vagina, along the anterior (fig. 493, *e*) and the posterior walls, a slightly elevated ridge extends from the lower end upwards along the middle line, similar to the raphé in other situations: these ridges are named the *columns* of the vagina, or *columnæ rugarum*. Numerous dentated transverse ridges, called *rugæ*, will also be observed, particularly in persons who have not borne children, running at right angles from the columns. These columns and rugæ, which are most evident near the entrance of the vagina, and gradually become less marked and disappear towards its upper end, are calculated to facilitate the enlargement of the vagina that occurs during pregnancy and parturition.

Structure and connexions.—The walls of the vagina are thickest in front, where the urethra is situated, which indeed may be said to be imbedded in the anterior wall of the vaginal passage; in other situations they are thinner. The vagina is firmly connected by cellular tissue to the neck of the bladder, and but loosely to the rectum and levatores ani muscles; at the upper end, for about a fourth part of its length, it receives a covering behind from the peritoneum, which descends in the form of a cul-de-sac thus far between the vagina and the rectum.

The external layer of which the vagina is composed is a dense, pale red, highly distensible and vascular cellular tissue, which adheres closely above to the tissue of the cervix uteri. Round the tube a layer of loose erectile tissue is found, which is most marked at the lower part.

At its lower end, the vagina is embraced by muscular fibres, which constitute the *sphincter vaginæ* (fig. 491, *b*). The fibres of this muscle are attached behind to the central point of the perineum, in common with the sphincter ani and transversus perinæi muscles; they open out to surround the vaginal orifice and vestibule, closely embracing on the outer side the two bulbs of the vestibule, and again approaching in front, become narrow and are inserted upon the corpora cavernosa of the clitoris, a fasciculus crossing over these and including the vena dorsalis. The two halves of this elliptical muscle appear to be strictly analogous to those of the bulbo-cavernosus muscle in the male.

The mucous membrane, besides the columns and rugæ, is provided with numerous muciparous glands and follicles, especially in its upper smoother portion: around the cervix uteri they are very numerous. This membrane, which is continuous with that of the uterus, is covered by a squamous epithelium.

The vagina is largely supplied with vessels and nerves. The arteries are derived from branches of the internal iliac, viz., the vaginal, internal pudic, vesical, and uterine (vol. i. pp. 610, 613). The veins correspond; but they first surround the vagina with numerous branches, and form at each side a plexus named the *vaginal* plexus. The *nerves* are

derived from the hypogastric plexus of the sympathetic, and from the fourth sacral nerve and pudic nerve of the spinal system; the former are traceable to the erectile tissue (vol. ii. p. 356).

UTERUS.

The *uterus, womb*, or *matrix* (fig. 492, *b*), is a hollow organ, having very thick walls, which is intended to receive the ovum, retain and support it during the development of the fœtus, and expel it at the time

Fig. 492.

Anterior view of the uterus and appendages.—*a*. Fundus, *b*, body, and *c*, cervix or neck of the uterus. *e*. Front of the upper part of the vagina. *n*, *n*. Round ligaments of the uterus. *r*, *r*. Broad ligaments. *s*, *s*. Fallopian tubes. *t*. Fimbriated extremity. *u*. Ostium abdominale. The position of the ovaries is shown through the broad ligaments; and also the cut edge of the peritoneum, along the lower border of the broad ligaments and across the uterus.

of parturition. During pregnancy this organ accordingly undergoes a great enlargement in size and capacity, as well as other important changes. It is a pear-shaped body, situated in the cavity of the pelvis, between the bladder and rectum, and projecting into the upper end of the vagina (*e*), with which it is intimately connected. In its ordinary condition the uterus does not reach above the brim of the pelvis. Its upper end is turned upwards and forwards, whilst the lower is in the opposite direction; so that its position corresponds with that of the axis of the inlet of the pelvis, and forms an angle or curve with the axis of the vagina, which corresponds with that of the cavity and outlet. The uterus projects, as it were, upwards into a fold of the peritoneum, by which it is covered behind and above, and also in front, except for a short distance towards the lower end, where it is connected with the base of the bladder. Its free surface is in contact with the other pelvic viscera, some convolutions of the small intestine usually lying upon and behind it. From its two sides the peritoneum is reflected in the form of a broad duplicature, named the ligamentum latum (*r*), which, together with the parts contained within it, will be presently described.

The fully developed virgin uterus, for to that condition of the organ the following description applies, is pyriform, but compressed from

before backwards, and, therefore, somewhat triangular, the base being turned upwards. Its average dimensions are about three inches in length, two in breadth at its upper and wider part, and nearly an inch in thickness: its weight is from seven to twelve drachms. It is usually described as consisting of the fundus, the body, and the neck.

The *fundus* (*a*) is the broad upper end which surmounts the body, and extends beyond the points of attachment of the Fallopian tubes. Its border is convex, and it is covered entirely with peritoneum. The succeeding part, or *body* (*b*), gradually narrows as it extends from the fundus to the neck; its two sides or borders are straight; its anterior and posterior surfaces are both somewhat convex, but the latter more so than the former. At the points of union of the sides with the rounded superior border or fundus, are two projecting angles, to which the Fallopian tubes are attached, the round ligaments being inserted a little before, and the ovarian ligaments behind and beneath them; all three of these parts being included in the duplicature of the broad ligaments. The lower, narrower, and more rounded portion of the uterus is named the *neck* or *cervix uteri* (*c*); it is from four to six lines long; it is continuous above with the body, and, becoming somewhat smaller towards its lower extremity, projects into the upper end of the tube of the vagina, which is attached all around to the substance of the uterus, but extends upwards to a greater distance behind than in front. The projecting portion is sometimes named the *vaginal part* (pars uteri vaginalis; fig. 493, *d*). The lower end of the uterus presents a transverse aperture, by which its cavity opens into the vagina; this is named variously *os uteri, os uteri externum*, and (from some supposed likeness to the mouth of the tench fish) *os tincæ*. It is bounded by two thick lips, which are distinguished by their relative position into anterior and posterior, the latter being the thinner and longer of the two. These borders or lips are generally smooth, but, after parturition, frequently become irregular, and are sometimes fissured or cleft.

Owing to the great thickness of its walls (fig. 493, *f*), the *cavity* of the uterus is very small in proportion to the size of the organ. The part corresponding with the body (*b*) is triangular, and flattened from before backwards, so that its anterior and posterior walls touch each other. The base of the triangle is directed upwards, and is curvilinear, the convexity being turned towards the interior of the uterus. This form is owing to the prolongation of the cavity through the substance of the organ towards its two superior angles (*i*), where two minute foramina will be observed, leading into the Fallopian tubes (*s*). At the point where the body is continuous below with the neck, the cavity is slightly constricted, and thus forms what is sometimes named the *internal orifice* (*os uteri internum, isthmus vel ostium uteri*); it is often smaller than the os externum, and is a circular opening. That portion of the cavity which corresponds to the *neck* (*c*) resembles a tube slightly flattened before and behind; it is somewhat dilated in the middle, and opens inferiorly into the vagina by the os tincæ. Its inner surface is marked by two longitudinal ridges or columns, which run, one on the anterior, the other on the posterior wall, and from both of

which, rugæ are directed obliquely upwards on each side, so as to present an appearance which has been named *arbor vitæ uterinus,* also *palmæ plicatæ.*

Structure.—The walls of the uterus consist of an external serous layer, an internal mucous membrane, and a proper intermediate tissue. The *peritoneal* layer covers the fundus and body, except at the sides and for about half an inch of the lower part of the body in front, which is attached to the base of the bladder.

The *proper tissue* of the uterus constitutes almost the entire substance of its walls, which are thickest opposite the middle of the body and fundus, and are thinnest at the entrances of the Fallopian tubes. The tissue is very dense; it is composed of bundles of muscular fibres of the plain variety, interlacing with each other, but disposed in bands and layers, intermixed with much fibro-cellular tissue, a large number of blood-vessels and lymphatics, and a few nerves. The cellular tissue is more abundant near the outer surface. The arrangement of the muscular fibres is best studied in the uterus at the full period of gestation, in which the bands and layers formed by them become augmented in size, and much more distinctly developed. They may be referred to three sets or orders, viz., external, internal, and intermediate. Those of the *external* set are arranged partly in a thin superficial sheet, immediately beneath the peritoneum, and partly in bands and incomplete strata, situated more deeply. A large share of these fibres arch transversely over the fundus and adjoining part of the body of the organ, and converge at either side towards the commencement of the round ligaments, along which they are prolonged to the groin. Others pass off in like manner to the Fallopian tubes, and strong transverse bands from an anterior and posterior surface are extended into the ovarian ligaments. A considerable number of thinly scattered fibres also pass at each side into the duplicature of the broad ligament, and others are described as running back from the cervix of the uterus into the recto-uterine folds or plicæ semilunares. The fibres of the subperitoneal layer are much mixed with cellular tissue, especially about the middle of the anterior and posterior surfaces of the uterus, in which situation many of the superficial fibres appear to have as it were a median attachment from which they diverge. The fibres on the *inner* surface of the uterus are disposed with comparative regularity in its upper part, being arranged there in numerous concentric rings round the openings of the two Fallopian tubes, the outermost and largest circles of the two series meeting from opposite sides in the middle of the uterus. Towards the cervix the internal fibres run more transversely; elsewhere they take various directions. The *intermediate* fibres, between the external and internal set, pass in bands among the blood-vessels, following no regular course.

The *mucous membrane* which lines the uterus is thin and closely adherent to the subjacent substance, especially in the body of the organ. It is continued from the vagina, and into the Fallopian tubes. Between the rugæ of the cervix, already described, it is provided with numerous mucous follicles and glands. There are also occasionally found in the same situation certain small transparent vesicular bodies,

which, from an erroneous opinion as to their nature, were named the *ovula of Naboth.* They appear to be closed and obstructed mucous follicles, distended with a clear viscous fluid.

In the body of the uterus the mucous membrane is thin, smooth, soft, and of a reddish-white colour. When seen by aid of a lens, it is found to be marked over with minute dots, which are the orifices of numerous simple tubular glands, somewhat like those of the intestine. Some of these tubular glands are branched, and others are slightly twisted into a coil. These glands can be distinctly seen in the unimpregnated and in the virgin uterus, but they become enlarged and more conspicuous on impregnation. The epithelium is columnar and ciliated as far down as the middle of the cervix, below which point it becomes squamous like that of the vagina and vulva.

Ligaments of the uterus.—Where the peritoneum is reflected off from the uterus to the rectum behind, and to the bladder in front, it forms, in each position, two semilunar folds, which are sometimes called respectively the *anterior* and the *posterior ligaments* of the uterus. The former are also named the *vesico-uterine*, and the latter, which are more marked, the *recto-uterine folds*, or *plicæ semilunares* of Douglas.

The *broad ligaments* (ligamenta lata, fig. 492, 493, *r*) are formed on each side by a fold of the peritoneum, which is directed laterally from the anterior and posterior surfaces of the uterus, to be connected

Fig. 493.

Posterior view of the uterus and its appendages: the cavity of the uterus being shown by the removal of its posterior wall; and the vagina being laid open.—*a.* Fundus, *b.* body, and *c.* cervix of the uterus, laid open. The arbor vitæ is shown in the cervix. *d.* The os uteri externum, laid open. *e.* The interior of the upper part of the vagina. *f.* Section of the walls of the uterus. *i.* Opening into Fallopian tube. *o.* Ovary. *p.* Ligament of ovary. *r.* Broad ligament. *s.* Fallopian tube. *t.* Fimbriated extremity.

with the sides of the pelvic cavity. The part intervening between the uterus and the pelvis on each side constitutes the ligamentum latum. Between the two layers of the serous membrane are placed, first, the Fallopian tube, which, as will be more particularly described, runs along the upper margin of the broad ligament; secondly, the round ligament, which is in front; thirdly, the ovary and its liga-

ment, which are behind; and, lastly, blood-vessels, lymphatics, and nerves, with some scattered fibres from the superficial muscular layer of the uterus. The *ligament of the ovary* (fig. 493, *p*) is merely a dense fibro-cellular cord, containing also, according to some authorities, uterine muscular fibres, and measuring about an inch and a half in length, which extends from the inner end of the ovary to the upper angle of the uterus, immediately behind and below the point of attachment of the Fallopian tube; it causes a slight elevation of the posterior layer of the serous membrane, and, together with the ovary itself, forms the lower limit of a triangular portion of the broad ligament, which has been named the *ala vespertilionis* or bat's wing (*r*).

The *round ligaments* are two cord-like bundles of fibres, about four or five inches in length, attached to the upper angles of the uterus, one on either side (ligamentum rotundum, lig. teres uteri; fig. 492, *n*, *n*), immediately in front of the Fallopian tube. From this point each ligament proceeds upwards, outwards, and forwards, to gain the internal inguinal ring; and after having passed, like the spermatic cord in the male, through the inguinal canal, reaches the fore part of the pubic symphysis, where its fibres expand and become united with the substance of the mons veneris. Besides cellular tissue and vessels, the round ligaments contain plain muscular fibres, like those of the uterus, from which, indeed, they are prolonged. Each ligament also receives a covering from the peritoneum, which, in the young subject, is prolonged under the form of a tubular process for some distance along the inguinal canal; this, which resembles the vaginiform process of peritoneum originally existing in the same situation in the male, is named the canal of Nuck: it is generally obliterated afterwards, but is sometimes found even in advanced life.

Blood-vessels and nerves.—The *arteries of the uterus* are four in number, viz., the right and left *ovarian* (which correspond to the spermatic of the male) and the two *uterine*. Their origin, as well as the mode in which they reach the uterus and ovaries, has been already described (vol. i. pp. 603, 611). They are remarkable for their frequent anastomoses, and also for their singularly tortuous course: within the substance of the uterus they seem to be placed in little channels or canals. The *veins* correspond with the arteries: they are very large and form the uterine plexuses, and their thin walls are in immediate contact with the uterine tissue. The course of the lymphatics is described in vol. ii. p. 51; they are very large and abundant in the gravid uterus. The *nerves* have been fully described (p. 356). They are derived from the inferior hypogastric plexuses, the spermatic plexuses, and the third and fourth sacral nerves.

The *changes which take place in the uterus* from age, menstruation, and gestation, and the characters presented by this organ after it has once performed the latter function, can only be very generally indicated here.

For some time after *menstruation* first commences, the uterus becomes rounder and slightly enlarged at each period, its os externum becomes more rounded, and its lips swollen: subsequently these periodical alterations are not so marked. The organ itself, however, always becomes more turgid with blood, and the mucous membrane appears darker, softened, and thickened.

In *gestation* more extensive alterations ensue, which necessarily affect the size,

shape, and position of the organ, the thickness and amount of substance in its walls, the dimensions and form of its cavity, and the character of its cervix and of its os externum and os internum. Its weight increases from about one ounce to one pound and a half or even three pounds. Its colour becomes darker, its tissue less dense, its muscular bundles more evident, and their fibres more characteristic. The round ligaments become enlarged, and their muscular structure more marked; the broad ligaments are encroached upon by the intrusion of the growing uterus between their layers. The mucous membrane and the glands of the body of the uterus become the seat of singular changes, which lead to the formation of the decidual membrane; whilst that of the cervix loses its columns and rugæ. The blood-vessels and lymphatics are greatly enlarged, and it is observed that the arteries become exceedingly tortuous, as they ramify upon the organ. The condition of the nerves in the gravid uterus has been already discussed (p. 356).

After parturition, the uterus again diminishes, but never regains its original virgin character. Its weight usually remains about two or three ounces in those who have had children; its cavity is larger; the os externum is more rounded, and its margins often puckered or fissured; the arteries continue much more tortuous than they are in the virgin; and its muscular fibres and layers remain more defined.

Age.—In the infant the neck of the uterus is larger than the body; and the fundus is not distinguished either by its breadth or its convex outline. These parts afterwards enlarge gradually, until, at puberty, the pyriform figure of the womb is fully established. The arbor vitæ is very distinct, and indeed at first reaches upwards to the highest part of the cavity.

From the gradual effects of *age* alone, independent of impregnation, the uterus shrinks, and becomes paler in colour, and harder in texture; its triangular form is lost; the body and neck become less distinguishable from each other; the orifices also become less characteristic.

THE OVARIES AND FALLOPIAN TUBES.

The *ovaries* (fig. 493, *o*, *o*), the parts analogous to the testicles of the male (ovaria, testes muliebres), are two somewhat flattened oval bodies, which are placed one on each side, nearly horizontally, at the back of the broad ligament of the uterus, and are enveloped by its posterior membranous layer. The ovaries are largest in the virgin state; their weight is from three to five scruples, and they usually measure about one inch and a half in length, three quarters of an inch in width, and nearly half an inch in thickness; but their size is rather variable. Each ovary is free on its two sides, and also along its posterior border, which has a convex outline; but it is attached along its anterior border, which is straighter than the other, and by which alone the vessels and nerves reach it. Its inner end is generally narrow, and is attached to the dense cord already described as the *ligament* of the *ovary* (*p*), by which it is connected with the uterus. Its outer extremity is more obtuse and rounded, and has attached to it one of the fimbriæ of the Fallopian tube (*s*).

Structure.—The colour of the ovaries is whitish, and their surface is either smooth, or more commonly irregular, and often marked with pits or clefts resembling scars. Beneath the peritoneal coat, which covers it everywhere except along its attached border, the ovary is enclosed in a *proper fibrous coat* (tunica albuginea), of a whitish aspect and of considerable thickness, which adheres firmly to the tissue beneath. When this latter is divided, it is seen to consist of a firm reddish-white vascular structure called the *stroma* (fig. 494 A,[1]), in

which are lodged a number of small vesicles of various sizes, named the *Graafian vesicles* or *follicles* (vesiculæ Graafianæ). In females

Fig. 494.

A B

A. Graafian vesicle of a mammal seated in the ovary, magnified:—(Baër).—1. Vascular stroma of the ovary. 2. Peritoneal coat of ovary. 3. Outer, and 4, inner tunics of Graafian vesicle. 5. Membrana granulosa of Baër. 6. Fluid in cavity of vesicle. 7. Granular disc of Baër. 8. The ovum.

B. Ovum of the sow, removed from the Graafian vesicle, and lying amongst granular matter. Magnified highly.—(Barry.)—1. Germinal spot of Wagner. 2. Germinal vesicle of Purkinjé. 3. The yolk. 4. The transparent tunic of ovum. 5. Tunica granulosa (Barry); granular disc (Baër). 6. Adherent granules.

who have not had children there are usually from eight to fifteen or twenty of these vesicles in each ovary, varying from the size of a pin's head to that of a pea. As many as thirty, and even fifty have been counted. They are filled with a clear, colourless, albuminous fluid (6), and the larger ones approach the surface of the ovary, on which they may sometimes be distinguished as semitransparent elevations. These vesicles are not the ova, as was formerly supposed, but each includes, besides its fluid contents, a small round vesicular body, first distinctly pointed out by Baër, which is the true *ovum* (8). Sometimes, though rarely, two ova have been found in one vesicle.

The vesicles of De Graaf have two coats, viz., an external vascular tunic (3) and an internal tunic, named the *ovi-capsule* (4), which is lined with a granular epithelial layer, the *membrana granulosa* (5). At first the ovule appears to be floating near the centre of the vesicle, but, in the mature condition of the latter, it approaches the internal surface of the ovi-capsule, and becomes embedded in a small flattened heap of granular substance (7), which there forms part of the membrana granulosa. By rupture of the vesicle the ovum escapes into the Fallopian tube, and is thus conveyed into the womb, while the ruptured vesicle becomes converted into a yellow mass, named a *corpus luteum*, which, after persisting for a time, dwindles down into a small fibrous cicatrix.

The *ovum* itself (fig. 494, A,[8] and B,) is a perfectly spherical body, very constant in size, being about $\frac{1}{120}$th of an inch in diameter; it consists of a thick, colourless, and transparent envelope, (zona pellucida, Baër; membrana pellucida) (4), which surrounds the substance of the yolk. Within the yolk (3), which is made up of granular matter, is situated a still smaller vesicular body, named the *germinal vesicle* (2), which is about $\frac{1}{720}$th of an inch in diameter; and in this again is an opaque spot, having a diameter only of $\frac{1}{3500}$ to $\frac{1}{2500}$th of an inch, and named the *germinal spot* (macula germinativa) (1).

The *Fallopian tubes* (figs. 492, 493, *s*, *s*).—These tubes (tubæ Fallopianæ uterinæ), which may be considered as ducts of the ovaries,

and which serve to convey the ovum from thence into the uterus, are inclosed in the free margin of the broad ligaments. They are between three and four inches in length. Their inner or attached extremity, which proceeds from the upper angle of the uterus, is narrow and cord-like; but from this point they soon begin to enlarge, and proceeding outwards, one on each side, pursue an undulatory course, and at length, having become gradually wider, they bend backwards and downwards towards the ovary, about an inch beyond which they terminate in an expanded extremity, the margin of which is divided deeply into a number of irregular processes named *fimbriæ*, of which one, somewhat longer than the rest, is attached to the outer end of the corresponding ovary. This wide and fringed end of the Fallopian tube, or rather *trumpet*, as the term "tuba" literally signifies, is turned forwards, and is named the *fimbriated extremity* (morsus diaboli, *t t*). In the midst of these fimbriæ, which are arranged in a circle, the tube itself opens by a round constricted orifice, *ostium abdominale* (fig. 492, *u*), placed at the bottom of a sort of fissure leading from that fringe which is attached to the ovary. It is by this orifice that an ovum is received at the time of its liberation from the ovary, and is thence conveyed along the uterine extremity of the tube, which opens into the womb by a very minute orifice, scarcely admitting a fine bristle, and named *ostium uterinum* (fig. 493, *i*). The part of the canal which is near the uterus is also very fine, but it becomes gradually larger to its abdominal orifice, where it is again somewhat contracted.

Beneath the external or peritoneal coat the walls of the tube contain, besides cellular tissue, plain muscular fibres like those of the uterus, arranged in an external longitudinal, and an internal circular layer. The mucous membrane lining the tubes is thrown into longitudinal plicæ, which are broad and numerous in the wider part of the tube; it is continuous, on the one hand, with the lining membrane of the uterus, and at the outer end of the tube with the peritoneum, presenting an example of the direct continuity of a mucous and serous membrane, and making the peritoneal cavity in the female an exception to the ordinary rule of serous cavities, *i. e.*, of being perfectly closed. The epithelium in the interior of the Fallopian tube is, like that in the uterus, columnar and ciliated; the inner surface of the fimbriæ is also provided with cilia, and Henlé has even detected ciliated epithelium on their outer or serous surface, but it here soon passes into the scaly epithelium of the peritoneal membrane.

Vessels and nerves of the ovaries and Fallopian tubes.—The ovaries are supplied by the ovarian *arteries*, analogous to the spermatic in the male (vol. i. p. 603), which anastomose freely by an internal branch with the termination of the uterine arteries (p. 611). Sometimes this anastomotic branch is so large that the ovary seems to be supplied almost entirely by the uterine artery. It always sends numerous branches to the Fallopian tube. The arteries penetrate the ovary along its attached border, pierce the proper coat, and run in flexuous parallel lines through its substance. The *veins* correspond, and the ovarian veins form a plexus near the ovary, named the pampiniform plexus (vol. ii. p. 29). The *nerves* are derived from the spermatic or

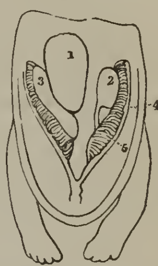
ovarian plexus; and also from one of the uterine nerves, which invariably send an offset to the Fallopian tube (p. 356.)

DEVELOPMENT OF THE GENITO-URINARY ORGANS.

The Urinary Organs.

The *Wolffian Bodies* and their *Excretory Ducts.*—The development of the genito-urinary organs in reptiles, birds, and mammalia, including man, is preceded by the formation of two *temporary* glands, named, after C. F. Wolff, the *Wolffian bodies.* In the embryos of the higher mammalia these organs are proportionally smaller, and disappear earlier than in those of the lower mammalia, birds, or reptiles. In the human subject, accordingly, the Wolffian bodies (fig. 495,[4]) are relatively small, and are found only in very early fœtuses. In the mammalian embryo, at a period when the intestinal canal still communicates with the umbilical vesicle, the Wolffian bodies commence in the form of two slight ridges of blastema, placed one on each side of the line of attachment of the intestine to the vertebral column. On reaching their full size, which in man seems to be about the fifth week of embryonic life, they have the appearance of two oblong reddish masses, placed on the sides of the vertebral column and extending from the lower end of the abdomen to the vicinity of the heart. Their structure is decidedly glandular; clear pedunculated vesicles may be early discovered in them, opening into an excretory duct, which runs along the outer side of each organ. These vesicles subsequently become lengthened into transverse and somewhat tortuous cœcal tubes, which open in like manner into the common duct. The Wolffian bodies are highly vascular, their larger blood-vessels running between and parallel with the transverse tubules. In the embryo of the coluber natrix, Rathké has observed little vascular tufts, which he compares to the Malpighian corpuscles of the kidneys.

Fig. 495.



Genito-urinary organs of a human embryo eight lines in length, magnified (Müller). 1. Supra-renal capsule of right side, which conceals the corresponding kidney. 2. Left kidney and ureter, exposed by removal of the left supra-renal capsule. 3. Right testis or ovary. 4. Wolffian body. 5. Vas deferens or Fallopian tube.

As to the *excretory duct,* Müller is of opinion, that in mammalia, it emanates from the lower end of the Wolffian body, but others agree in stating, that, as in birds, it lies along the outer border of the gland, receiving the tubules in its course. The ducts of the two bodies open into the sac of the allantois, to be presently described.

A whitish secretion has been seen in the ducts of the Wolffian bodies of birds and serpents resembling the urine of those animals, and since, also, the fluid of the allantois has been found to contain uric acid, it is thought that the Wolffian bodies perform the office of kidneys during the early part of fœtal life. They are accordingly sometimes named the *primitive* or *primordial kidneys.*

As development advances, the Wolffian bodies ([4]) rapidly become shorter and thicker in proportion; they shrink towards the lower part of the abdominal cavity, and soon become almost entirely wasted. By the end of the second month scarcely any trace of them is visible in the human embryo. They take no part in the formation of the kidneys ([2]) or suprarenal capsules ([1]), nor in that of the ovaries or body of the testis ([3]). Remnants of the tubular structure of these temporary organs are, however, to be found in female embryos, situated in the fold of peritoneum, connecting the ovary with the Fallopian tube (fig. 496, c,[5]). Similar appearances of tubuli, with rounded corpuscles intermixed, are met with in the same situation, at later periods of intra-uterine life, and even for some time after birth, constituting what is named the *organ of Rosenmüller,* a structure which J. F. Meckel regarded as an abortive or rudimentary epididymis. Kobelt maintains that a remnant of the Wolffian body persists throughout life, forming in the adult female an appendage to the ovary (*Neben-Eyerstock*) analogous

to the epididymis of the male. It is, moreover, supposed by Rathké, that, in the male, the middle tubuli of each Wolffian body, together with its excretory duct, become converted into the epididymis and vas deferens of the corresponding side; and Kobelt has adopted a similar view as to the origin of the epididymis. Lastly, it has been held by Müller, that in mammalia the lower portion of the excretory duct of the Wolffian body persists as part of the corresponding Fallopian tube or vas deferens.

The *Kidneys* and *Ureters*.—The *kidneys* commence subsequently to and independently of the Wolffian bodies. They first appear, it is said, about the seventh week, as two small dark oval masses, situated behind the upper part of the Wolffian bodies, which are still large, and completely hide the kidneys. Though at first smooth and oval (fig. 495,[2]), the kidneys soon assume their characteristic general outline, and about the tenth week are distinctly lobulated (fig. 496, A,[2]). The separate lobules, generally about fifteen in number, gradually coalesce in the manner already described (p. 509); but at birth, indications of the original lobulated condition of the kidney are still visible on the surface, and the entire organ is more round in its general figure than in the adult. The kidneys are then also situated lower down than in after life.

The formative blastema of the kidney, as observed by Rathké in the fœtal calf, soon contains a series of club-shaped bodies which have their larger ends free and turned outwards, and their smaller ends or pedicles directed inwards towards the future hilus, where they are blended together. As the organ grows these bodies increase in number, and finally, becoming hollow, form the *uriniferous tubes*. At first, short, wide, and dilated at their extremities, the tubuli soon become elongated, narrow, and flexuous, occupying the whole mass of the kidney, which then appears to consist of cortical substance only. At a subsequent period, the tubuli nearest the hilus become straighter, and thus form the medullary substance. The tubuli, as shown by Valentin, are absolutely, as well as relatively, wider in an early condition of the kidney. The Malpighian corpuscles have been seen by Rathké in a sheep's embryo, the kidneys of which measured only two and a half lines in length.

The *ureters*, it is stated by Rathké, commence *after* the kidneys, and then become connected with the hilus of each organ, and with the narrow ends of the club-shaped bodies in its interior. At first the growing tubuli do not seem to communicate with the cavity of the ureter; but subsequently, when the wide upper portion of this canal or *pelvis* of the kidney has become divided to form the future *calices*, the pencil-like bundles of the tubuli open into each subdivision of the ureter, and give rise at a later period to the appearance of the *papillæ* and their numerous orifices. The lower ends of the ureters soon come to open into that part of the sac of the allantois, which afterwards becomes converted into the bladder. The researches of Müller, Valentin, and Bischoff are in general confirmatory of Rathké's account; Valentin, however, believes that the ureter (which he has seen at the earliest periods), the pelvis of the kidney, and the uriniferous tubules are formed in a general blastema, independently of one another; and that, each part first becoming separately hollowed out, their cavities afterwards communicate with each other. Bischoff states that the ureters appear at the same time as the kidneys, and are formed in continuity with the uriniferous tubules, and moreover that all these parts, which are at first solid, are excavated, not separately but in common, in the further progress of development.

In the advanced fœtus and in the new-born infant, the kidneys are relatively larger than in the adult, the weight of both glands compared with that of the body, being, according to Meckel, about one to eighty at birth.

The Suprarenal Capsules.—Arnold alone has supposed that these organs are formed from a part of the Wolffian bodies severed from the rest. Mr. Goodsir is of opinion that they are remnants of the primitive blastodermic membrane. Other observers attribute to these organs an independent origin. Valentin describes them as originating in a single mass, placed in front of the kidneys, and afterwards becoming divided. Meckel has also seen them partially blended together. Müller has found the suprarenal capsules in contact, but not united. Bischoff has always seen them separate, and in early conditions closely applied to the upper end of the Wolffian bodies.

In quadrupeds, the suprarenal capsules are at all times smaller than the kidneys; but in the human embryo (figs. 495, 496, A,[1]) they are for a time larger than those organs, and quite conceal them. At about the tenth or twelfth week, the renal capsules are smaller than the kidneys; at birth the proportion between them is 1 to 3, whilst in the adult it is about 1 to 22. They diminish in aged persons.

The Allantois, Urinary Bladder, and Urachus.—The name of Allantois was originally given to a membranous sac which is appended to the umbilicus of various quadrupeds in the fœtal state, and which communicates with the urinary bladder by means of a canal passing through the umbilical aperture and named the urachus. These several parts are formed out of one original saccular process, which passes out from the cloacal termination of the intestine, and which subsequently becomes distinguished into the bladder, the urachus and the allantois strictly so called; and modern embryologists employ the term allantois also to signify the original common representative of the different parts referred to. In this sense an allantois may be said to exist not only in mammalia, but also in birds and reptiles, subject, however, to great differences in its subsequent development and relative importance. Thus in Batrachians it does not extend out of the body at all; in scaly reptiles, on the other hand, as well as in birds and in some quadrupeds, it ultimately surrounds the body of the fœtus and spreads itself over the inner surface of the chorion; whilst in other quadrupeds its extra-abdominal portion is of small extent. In man the allantois proper is not only very insignificant in point of size, but also extremely limited in duration, for it vanishes at a very early period in the life of the embryo; and whilst in many animals it serves both as a receptacle for the secretion of the fœtal urinary organs, and as a vehicle to conduct the umbilical vessels from the body of the embryo to the chorion to form the placenta (or some equivalent vascular structure), it seems in the human species to serve merely for the latter purpose. The allantoid process communicates below with the intestinal canal, and receives the wide excretory ducts of the Wolffian bodies, the ureters, and the Fallopian tubes or vasa deferentia. By Baer, Rathké, and others, the allantois has been regarded as formed from the intestinal tube, and by Reichert as developed upon the excretory ducts of the Wolffian bodies. Bischoff says that, in the embryos of the rabbit and dog, it commences before the appearance of either the Wolffian bodies or the intestine, as a solid mass projecting forwards from the posterior extremity of the body. This mass soon becomes hollowed into a vesicle, which is covered with blood-vessels, and communicates with the intestine. Continuing rapidly to enlarge, it protrudes between the visceral plates, and, when these close together, through the opening of the umbilicus, forming in the rabbit a pear-shaped sac, which conveys blood-vessels (soon recognised as the umbilical vessels) to the chorion to form the fœtal part of the placenta.

In the human embryo, the portion of the allantois situated beyond the umbilicus disappears entirely at a very early period, and the internal portion, reaching from the umbilicus to the intestine, is first elongated, and then becomes widened below to form the bladder, whilst its upper part shrinks, and is at length completely closed to form the urachus; but, even up to the period of birth, the urachus often remains tubular for a certain distance above the bladder. The account of the metamorphosis of the allantois given recently by Dr. M. Langenbeck is somewhat different. That observer states that the wide part of the allantois, originally outside the body of the embryo, is not obliterated, but is drawn into the abdominal cavity, its remote portion having previously become constricted to form the future urachus, whilst the part nearest the embryo, together with the narrow portion already within the fœtus, is destined to form the bladder.

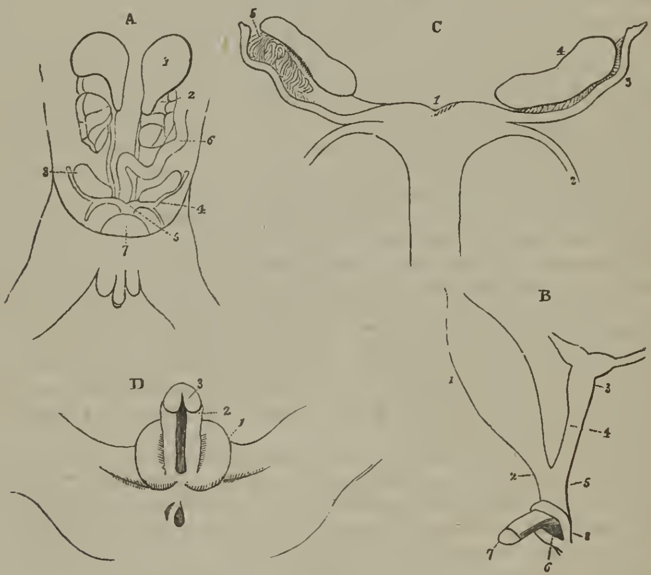
The lower part of the allantois, or rudimentary bladder, receiving as already mentioned the efferent canals of the Wolffian bodies, as well as those of the kidneys and of the ovaries or testes, at first communicates freely with the lower end of the intestinal tube, and when this becomes opened to the exterior, there is formed a sort of cloaca, as in adult birds and reptiles. Soon, however, a separation takes place, and the genito-urinary organs have a distinct passage to the exterior, named the *sinus uro-genitalis*, (fig. 496, B ,) situated in front of the termination of the intestine.

The Organs of Generation.

The development of the parts concerned in the reproductive function does not begin until after the rudiments of the principal organs of the body have appeared. The internal organs of generation first commence, and for a brief period no sexual difference is perceptible in them. The external organs, which subsequently begin to be formed, are also identical in appearance, in the two sexes, as late as the fourteenth week.

The *Internal Organs of Generation.* The *Ovaries* and *Testes.*—The rudiments of the *ovaries* or *testes*, for it cannot at first be determined which are ultimately to be produced, appear after the formation of the allantois and Wolffian bodies, but a little sooner than the kidneys. They consist of two small whitish oval masses of blastema (fig. 495,^{3}), placed on the inner border of the Wolffian bodies. The earliest peculiarities of sex which are distinguishable, occur in the form, position, and structure of these rudiments of the essential reproductive organs. The ovaries, for example, become elongated and flattened, and soon assume first an oblique and then a nearly transverse position (fig. 496, A,^{3}): the testes, on the

Fig. 496.



Genito-urinary organs of a female embryo, measuring three inches and a half in length. (Müller.) A. General view. 1. Left supra-renal capsule. 2. Left kidney. 3. Right ovary. 4. Left Fallopian tube. 5. Uterus. 6. Intestine. 7. Bladder. B. Genito-urinary organs viewed from one side and enlarged. 1. Bladder. 2. Urethra. 3. Uterus, bifid. 4. Vagina. 5. Part common to the vagina and urethra, or sinus urethro-genitalis. 6. Common orifice of the urethra and genital organs. 7. Clitoris. C. Internal organ, still further magnified. 1. Uterus, bifid, or with the fundus notched. 2. Round ligament. 3. Fallopian tube. 4. Ovaries. 5. Remains of Wolffian bodies. D. External parts, also magnified. 1. Labia majora. 2. Nymphæ, leading down from the under side of the clitoris. 3. Glans clitoridis.

other hand, become rounder and thicker, and retain their nearly vertical direction. Moreover, as development advances, the ovaries remain unconnected with the Fallopian tubes, whilst the testes become united with the corresponding excretory canals or vasa deferentia. Lastly, though both ovaries and testicles gradually change their original position, and become situated lower down than at first, the

former merely descend to the pelvic cavity, whilst the latter pass through the inguinal canal and enter the scrotum.

The changes which take place in the substance of the ovary and testis have been minutely described by Valentin, who has endeavoured to trace the analogies in the development of each. Bischoff, however, has not succeeded in confirming Valentin's description, and their respective statements leave the subject yet in doubt. In the human female, according to Bischoff, the Graafian vesicles are not usually visible in the ovarian stroma before birth, but exceptions to this rule occasionally occur. The ovum begins to form in its Graafian vesicle, when this latter is still very small; it soon nearly fills the vesicle, which, however, grows more rapidly afterwards, so as at length to acquire a much greater proportionate size. The development of new Graafian vesicles seems to continue as long as the procreative faculty subsists, but beyond the age of puberty it is difficult to detect them in their commencing state.

The *Tubæ Fallopianæ* and *Vasa deferentia*.—The mode of origin of the Fallopian tubes and vasa deferentia has been differently explained by different inquirers. In the female embryo of birds, according to Müller, the oviduct (or Fallopian tube) is formed along the outer border of the Wolffian body, close to but independently of the duct of that gland; whereas, in the male embryo of the bird, no independent vas deferens could be detected, but the excretory duct of the Wolffian body appeared to become connected by transverse vessels with the corresponding testicle, and to form its vas deferens. In mammalia, on the other hand, in which the excretory duct of the corpus Wolffianum is described by Müller as passing out at its lower end, the Fallopian tube, as well as the vas deferens, is supposed by that observer to be formed out of a distinct canal, which has the appearance of a filament running along the outer border of the Wolffian body, and which ultimately becomes continuous below with a persistent portion of the Wolffian duct. In opposition to this view, Rathké maintained that both the Fallopian tubes and deferent vessels are formed altogether independently of the excretory ducts of the Wolffian bodies, though their rudiments are developed close to those ducts, the situation of which they ultimately come to occupy. Rathké has since been led to adopt a somewhat different opinion: according to this view, which is founded on his researches on the development of the snake, but which he thinks will probably apply also to the higher vertebrata, there is formed along the Wolffian duct in both sexes, a solid filament, which is afterwards converted into a canal open at its upper end. In the female, the duct of the Wolffian body, as well as that body itself, is entirely absorbed, whilst the new canal constitutes the Fallopian tube; but, in the male, the reverse takes place, the newly formed canal disappearing, and the Wolffian duct becoming the vas deferens, whilst some of the tubuli of the Wolffian body remaining in connexion with the duct, probably contribute to form the epididymis. Bischoff, after a careful examination of these parts, declares that the filament formed along the outer border of each Wolffian body, contains not only the excretory duct of that gland, but an efferent sexual canal, which is the rudiment of the Fallopian tube or vas deferens, and that these parts are both formed altogether independently of the Wolffian duct.

In the female embryo, the efferent sexual canal (fig. 495,[5]) or future *Fallopian tube*, becomes widened, remains open at its upper end, is comparatively short and free from convolutions, and is only slightly attached to the corresponding ovary (fig. 496, A, C). In the male, on the contrary, the efferent duct, or *vas deferens*, continues of comparatively narrow calibre, connects itself with the testicle, and forms the epididymis, becoming lengthened out and convoluted. Muller also thinks that no part of the Wolffian bodies is converted into the generative organ in either sex. He supposes that the efferent sexual tube or vas deferens becomes connected with the testicle by means of transverse tubuli which do not belong to the Wolffian body, and that these communicating tubes form the coni vasculosi, whilst the rest of the epididymis is formed by the convolutions of the efferent tube itself. It has already been mentioned that Rathké, and, more recently, Kobelt, are of opinion that the junction of the vas deferens with the testis, is effected by means of some of the transverse tubuli of the corresponding Wolffian body which persist and form the epididymis.

The *descent of the testicles* is a term applied to the passage of the testes from the

abdominal cavity into the scrotum. When yet situated at the back of the abdomen, along the inner border of the Wolffian bodies, the testes are covered in front by the peritoneum; and, besides this, soon acquire a proper envelope, which becomes the tunica albuginea. At this period, the blood-vessels and nerves, and, subsequently, the efferent apparatus of the gland or future vas deferens and epididymis, pass to or from the posterior surface of the testis, which is destitute of peritoneal covering. Even before the wasting of the corpora Wolffiana, a slight opaque band or cord lying beneath the peritoneum is seen extending from the lower part of each of these bodies to the inguinal region. When the Wolffian bodies have disappeared, each testis, now increased in size, and connected with its excretory duct, has already moved somewhat lower down in the abdomen of the embryo, and is supported by a suspensory fold or duplicature of the peritoneum, named by Seiler the *mesorchium*. By this time, the opaque cord just mentioned has become much larger, and reaches from the lower end of the epididymis and testis through the inguinal canal to the front of the pubes and to the scrotum, constituting the *gubernaculum testis*, so called because it is supposed to serve as a guide to the testicle in its descent. At the fifth or sixth month of fœtal life, the gubernaculum has attained its full development; its upper end, on which the testicle rests, is broader than the lower part, and lies in the peritoneal fold or mesorchium. As the testicle passes from the lumbar region to the iliac fossa, the gubernaculum becomes shorter, and before the gland enters the internal inguinal ring, which takes place in the seventh month, a small pouch of peritoneum appears at that point, and, under the name of the *processus vaginalis peritonæi*, precedes the testicle in its course through the inguinal canal, and enters the scrotum in advance of the gland. By the end of the eighth month the testis is in the scrotum, and a little time before birth, the narrow neck of the peritoneal pouch, by which it previously communicated with the general peritoneal cavity, becomes closed in the manner elsewhere described (p. 543), and the process of peritoneum, now entirely shut off from the abdominal cavity, remains as an independent serous sac, named the *tunica vaginalis*. It has also been noticed elsewhere, that some of the lowermost fibres of the internal oblique muscle, and even of the transversalis muscle also, appear to be carried down in front of the testicle, to form the *cremaster* muscle.

The office of the gubernaculum is yet imperfectly understood. Hunter, Cooper, Seiler, and others, believed that it contained muscular fibres, which drew the testicle into its new position. Some have supposed that it effected this by a slow and gradual contraction or shortening of its tissue; whilst a third opinion has been, that it merely serves as a guide to the path of the gland. The muscularity of the gubernaculum has been denied by many anatomists, who regard this cord as either cellular or fibrous: it often appears to be partially hollow. According to Mr. Curling, who has recently examined it, it consists of a soft transparent areolar tissue within, and of distinct striped muscular fibres externally. At its lower end, the gubernaculum and these muscular fibres are arranged in three bundles, which are connected respectively with Poupart's ligament, the bottom of the scrotum, and the pubes: some fibres, moreover, are derived from the internal oblique muscle. In the opinion of Mr. Curling, these muscular bundles aid in the descent of the testicle, and afterwards form the cremaster. According to E. H. Weber, the gubernaculum originates in form of a sac filled with fluid and placed in the situation of the inguinal canal. The lower end of this sac is protruded downwards to the bottom of the scrotum: the upper end is extended upwards through the internal abdominal ring, as high as the testicles, passing in the fold of peritoneum by which that organ is suspended, and carrying up along with it some fibres from the internal oblique muscle. Weber conceives that the descent of the testicle is effected by means of an inversion, or as it were an intussusception of the hollow gubernaculum, which inversion commences at the upper orifice of the inguinal canal.* In the female embryo, a small cord, corresponding with the commencing gubernaculum in the male, is seen descending to the inguinal region, and ultimately becomes the round ligament of the uterus. It is accompanied by a pouch of peritoneum analogous to the processus vaginalis of the male, and named the canal of Nuck. (See p. 544.)

* Müller's Archiv., 1847, p. 403.

Transformation of the *uro-genital sinus*. Formation of the *female urethra, vagina*, and *uterus*, and of the *prostatic portion* of the male *urethra*, the *prostate*, *utriculus virilis*, and *vesiculæ seminales*.—After the disappearance of the Wolffian bodies, the *sinus uro-genitalis*, formed by the shutting off of the lower part of the allantois from the tube of the intestine, receives, in either sex, only two efferent canals on each side, viz., the ureters, and the Fallopian tubes or the vasa deferentia.

In the *female* embryo, this common genito-urinary passage (fig. 496, B,[5]) becomes divided at the bottom into an anterior part, *pars urinaria*, which receives the ureters and ultimately forms the neck of the bladder and the *urethra* ([2]), and a posterior part, *pars genitalis*, or proper genital passage, which receives the Fallopian tubes and represents the commencing *vagina* ([4]). The urethra and vagina both open into a still common part or *vestibule* of the genito-urinary passage.

The Fallopian tubes (fig. 496, C,[3]) coalesce at their lower ends so as to form a single median cavity, and thus give rise to the *uterus* ([1]), or at least to the upper part of that organ, for some observers describe the lower part and cervix as being formed by the upper end of the genital passage, or by a protrusion from it; the lower part of that passage, according to this view, becoming the vagina. For some time the uterus in the human subject continues to be bifid or two-horned, as in many quadrupeds, but, after the end of the third month, the angle between the orifices of the Fallopian tubes begins to be effaced, and the *fundus* is subsequently completed. Sometimes the bifid uterus continues through life. In the latter months of intra-uterine existence, the cervix uteri is much larger in proportion than the body and fundus, and, with the os uteri, projects into the vagina.

In the *male* embryo, the urinary part of the uro-genital sinus takes the form of a short canal, which represents the *neck of the bladder* with the *prostatic portion of the urethra*. The proper genital passage is formed, according to Rathké, by a conical protrusion of the walls of the common sinus at the place where the deferent ducts open. This observer supposes that the *vesiculæ seminales* begin as two small lateral protrusions from the genital passage at some distance apart from the openings of the vasa deferentia, but that, by the subsequent shortening and eventual median division of the intervening part of the passage, each seminal vesicle comes at length to open into the urethra in conjunction with the deferent duct of its own side. Bischoff believes that the so-called protrusion is due to an increased thickness of the terminations of the vasa deferentia, that the vesiculæ seminales are developed, each from its own vas deferens, and that the thickening of the lower ends of the deferent vessels has some connexion with the formation of the *prostate* gland. The recent researches of E. H. Weber, elsewhere referred to (p. 535), would seem to show that the part of the genital passage which in the female is converted into the lower portion of the uterus, remaining, as it were, in a rudimentary condition in the male, constitutes the little pouch, named the *sinus pocularis* or *utriculus virilis*, the lips of which, as it were, project into the prostatic portion of the urethra and form the *verumontanum*.

The *External Organs* of Generation.—As already stated, these do not begin to be formed until after the internal organs, and, for some time, they have the same form in both sexes.

Up to the fifth week, according to Tiedemann, there is no genito-urinary orifice, and indeed no anus. About the beginning of the sixth week, there is a common opening, for the intestine, the generative and the urinary organs, *i. e.*, a sort of *cloacal* aperture. In front of this simple opening, there soon appears a small recurved projecting body, which, as it enlarges, becomes grooved along the whole of its under surface. This is the rudimentary *clitoris* (fig. 496, D,[3]) or *penis*, at the summit of which an enlargement is formed which becomes the *glans*. The margins of the groove seen on its under surface are continued backwards on either side of the common aperture, which is now elliptical, and is bounded laterally by two large cutaneous folds. Towards the tenth or eleventh week, a transverse band, the commencing *perineum*, divides the anal orifice from that of the genito-urinary passage, which latter now appears as a rounded aperture, placed below the root of the rudimentary clitoris or penis, and between the prolonged margins of the groove beneath that organ. This opening, but not the clitoris or penis, is concealed by the large cutaneous folds already mentioned. In this condition, which continues until the fourteenth week, the parts appear

alike in both sexes, and resemble very much the perfect female organs. The rudiments of *Cowper's glands* are, it is said, seen at an early period, near the root of the rudimentary clitoris or penis, on each side of the genito-urinary passage.

In the female, the two lateral cutaneous folds enlarge, so as to cover the clitoris and form the *labia majora* (fig. 496, D,[1]). The clitoris itself becomes relatively smaller, and the groove on its under surface less and less marked, owing to the opening out and subsequent extension backwards of its margins to form the *nymphæ* ([2]). The *hymen* begins to appear about the fifth month. Within the nymphæ, the urethral orifice, as already mentioned, becomes distinct from that of the vagina.

In the male, on the contrary, the *penis* continues to enlarge, and the margins of the groove along its under surface gradually unite from the primitive urethral orifice behind, as far forward as the glans, so as to complete the long canal of the male *urethra*. This is accomplished about the fifteenth week. When this union remains incomplete, the condition named hypospadias is produced. In the mean time the *prepuce* is formed, and, moreover, the lateral cutaneous folds also unite from behind forwards, along the middle line or *raphé*, and thus complete the *scrotum*, into which the testicles do not descend until the last month of fœtal existence.

MAMMARY GLANDS.

The mammary glands (mammæ), the organs of lactation in the female, are accessory parts to the reproductive system. They give a name to a large class of animals (Mammalia), which are distinguished by their presence. When fully developed in the human female, they form, together with the integuments and a considerable quantity of fat, two rounded eminences (the breasts) placed one at each side on the front of the thorax. These extend from the third to the sixth or seventh rib, and from the side of the sternum to the axilla. A little below the centre of each breast, on a level with the fourth rib, projects a small conical body named the *nipple* (mamilla), which points somewhat outwards and upwards. The surface of the nipple is dark, and around it there is a coloured circle or *areola*, within which the skin is also of a darker tinge than elsewhere. In the virgin these parts are of a rosy pink colour, but they are always darker in women who have borne children. Even in the second month of pregnancy the areola begins to enlarge and acquire a darker tinge; these changes go on increasing as gestation advances, and are considered useful and important signs in judging of suspected pregnancy. After lactation is over, the dark colour subsides, but not entirely. The skin of the nipple is marked with many wrinkles, and is covered with papillæ; besides this, it is perforated at the tip with several foramina, which are the openings of the lactiferous ducts; and near its base, as well as upon the surface of the areola, there are scattered rounded elevations, which are caused by the presence of little glands with branched ducts, four or five of which open on each tubercle. The tissue of the nipple contains a large number of vessels, and its papillæ are highly sensitive; it is capable of a certain degree of erection from mechanical excitement, and this is generally ascribed to turgescence of its vessels, which some regard as forming a species of erectile tissue.

The base of the mammary gland, which is nearly circular, is flattened, or slightly concave, and has its longest diameter directed upwards and outwards towards the axilla. It rests on the pectoral

muscle, and is connected to it by a layer of cellular tissue. The thickest part of the gland is near the centre, opposite the nipple, but the full and even form of the breasts depends chiefly on the presence of a large quantity of fat, which lies beneath the skin, covers the substance of the gland, and penetrates the intervals between its lobes and lobules. This fatty tissue, which is of a bright yellow tinge and rather firm, is divided into lobulated masses by numerous laminæ of fibrous or very dense cellular tissue, which are connected with the skin on the one hand, and on the other with the firm cellular investment of the gland itself, and that is connected behind by similar laminæ with the cellular membrane covering the pectoral muscle: these laminæ serve to support the gland. Beneath the areola and the nipple there is no fat, but merely the firm cellular tissue and vessels surrounding the lactiferous ducts.

Structure.—The mammary gland consists of a number of distinct glandular masses or lobes, each having a separate excretory duct, held together by a very firm intervening fibrous or cellular tissue, and having some adipose tissue penetrating between them. Each of these divisions of the gland is again subdivided into smaller lobes, and these again into smaller and smaller lobules, which are flattened or depressed, and held together by cellular tissue, blood-vessels, and ducts. The substance of the lobules, especially as contrasted with the adjacent fat, is of a pale reddish cream-colour, and is rather firm. It is composed principally of the vesicular commencements of the lactiferous ducts, which appear like clusters of minute rounded cells, having a diameter from ten to thirty times as great as that of the capillary vessels by which they are surrounded. These cells open into the smallest branched ducts, which, uniting together to form larger and larger ones, finally end in the single excretory canal corresponding to one of the chief subdivisions of the gland. The canals proceeding thus from the principal lobes composing the gland, are named the *galactophorous ducts*, and are fifteen to twenty in number; they converge towards the areola, beneath which they become considerably dilated, especially during lactation, so as to form sacs or sinuses two or even three lines wide, which serve as temporary though small reservoirs for the milk. At the base of the nipple all these ducts, again reduced in size, are assembled together, those in the centre being the largest, and then proceed side by side, surrounded by cellular tissue and vessels, and without communicating with each other, to the summit of the mamilla, where they open by separate orifices, which are seated in little depressions, and are smaller than the ducts to which they respectively belong. According to Pappenheim, the walls of the ducts are composed of cellular tissue, and of longitudinal and transverse elastic filaments. The mucous membrane is continuous with the common integument at the orifices of the ducts; its epithelium is scaly or tessellated, and in the smallest ducts and their ultimate vesicles consists of cells having a diameter very little exceeding that of their nucleus.

Blood-vessels and nerves.—The *arteries* which supply the mammary glands are the long thoracic and some other branches of the axillary

artery, the internal mammary, and the subjacent intercostals. The *veins* have the same denomination. Haller described a sort of anastomotic venous circle around the base of the nipple as the *circulus venosus*. The *nerves* are the anterior and middle intercostal cutaneous branches: Müller could not detect any sympathetic nerves accompanying the arteries; but it is probable that they exist.

In the *male*, the mammary gland and all its parts exist, but quite in a rudimentary state, the gland itself measuring only about six or seven lines across, and two lines thick, instead of four inches and a half wide and one and a half thick, as in the female. Occasionally the male mamma, especially in young subjects, enlarges and pours out a thin watery fluid; and, in some rare cases, milk has been secreted.

Varieties.—Two or even three nipples have been found on one gland. An additional mamma is sometimes met with, and even four or five have been observed to co-exist; the superadded glands being most frequently near the ordinary ones, but sometimes at a distant part of the body, as the axilla, thigh, or back.

SURGICAL ANATOMY.

THE surgical anatomy of a large portion of the body has been already discussed in connexion with the principal arteries (vol. i. p. 538, *et seq.*), but it remains to review certain parts of the walls of the abdomen and pelvis, with reference to surgical operations in which the viscera of those cavities are from time to time concerned.

SURGICAL ANATOMY OF THE PARTS CONCERNED IN CERTAIN ABDOMINAL HERNIÆ.

The walls of the abdomen, when in a healthy state, unaffected by injury, disease or malformation, retain under all circumstances the viscera within the cavity, except where certain natural openings exist for the passage of blood-vessels; but, at such openings, protrusions of the viscera, constituting the disease named "hernia" or "rupture," are liable to occur under the influence of the compression to which the organs are subjected during the production of efforts. For the replacement of the viscus so protruded, an accurate acquaintance with the structure of the part through which the protrusion takes place is required by the surgeon; and, on this account, a separate examination of the seat of each accident as a surgical region becomes necessary.

Two of the openings by which herniæ escape from the abdomen are situated close together at the groin. One is the canal in the lower part of the broad abdominal muscles, which, in the male, gives passage to the duct and vessels of the testis (spermatic cord), and in the female to the round ligament of the womb. The second opening exists at the inner side of the large femoral blood-vessels.

Hernial protrusions are likewise found to escape at the umbilicus, in the course of the blood-vessels which occupy that opening in the fœtus or in the immediate neighbourhood of the opening, and at the thyroid foramen where the obturator vessels and nerve pass downwards to the adductor muscles of the thigh. According to the situation they occupy these herniæ are named respectively inguinal, femoral, umbilical, and obturator. They will now be separately noticed; but, inasmuch as the structure of the parts connected with the umbilical and obturator herniæ is by no means intricate, and as, moreover, it is noticed with sufficient detail in text-books of practical surgery, it will be unnecessary to refer further to those forms of hernia in this work.

Before details are entered upon, it should be understood that as the various structures which are about to be reviewed in connexion, have been described in former parts of this treatise, with the systems to which they severally belong, we shall here for the most part only refer back to details already given, occasionally however recalling the most important facts, and adding such points as may be material to

the object with which the same structures are now brought under consideration.

OF THE PARTS CONCERNED IN INGUINAL HERNIA.

The inguinal hernia, it has been stated above, follows the course of the spermatic cord from the cavity of the abdomen. We shall therefore, before adverting to the hernial protrusions, examine the structure of the abdominal walls in the neighbourhood of the canal in which the cord is placed; and for this purpose it will be supposed that the constituents of those walls are successively laid bare and everted to such extent as would be permitted by two incisions made through them, and reaching, one along the linea alba for the length of three or four inches from the pubes, the other directed from the upper end of the vertical incision outwards to the superior spine of the ilium.

The *superficial fascia*—for the detailed description of which see vol. i. p. 302—is connected along the fold of the groin with Poupart's ligament and the upper end of the fascia lata; and, after descending over the spermatic cord into the scrotum, it becomes continuous with the membrane of the same kind which covers the perineum. Its thickness varies much in different persons, on account of the different quantity of fat contained within its meshes; but in the scrotum the fascia is devoid of fat; as it also is elsewhere towards the internal surface, where its density is at the same time augmented. From the various thickness of this structure on the abdomen and the scrotum, as well as in different persons, it will be inferred that the depth of incision required to divide it in an operation must vary considerably.

The *superficial vessels* of the groin are encased by the fascia, and are held to separate it into two layers. The vessels which ramify over the inguinal canal and the scrotum are the external pudic and epigastric arteries and veins (p. 619, vol. ii. p. 27). The veins, especially the epigastric, are considerably larger than the arteries they accompany. Some of these vessels are wounded in operations performed for the relief of strangulated hernia; but the bleeding from them is small in quantity and rarely requires the application of a ligature or other means to arrest it. The lymphatic glands of the groin (see p. 50) admit of being arranged into two sets, one being placed over Poupart's ligament and parallel with that structure; while the other series is upon the upper part of the thigh at its middle, about the saphenous opening in the fascia lata.

When the superficial fascia is removed the aponeurosis of the *external oblique muscle* (see p. 414) is in view, together with, in the male body, the spermatic cord (in the female body, the round ligament of the uterus), which emerges from an opening close to the outer side of the spine of the pubes (fig. 497). The lowest fibres of the aponeurosis as they approach the pubes become separated into two bundles, which leave an interval between them for the passage of the cord or ligament just named. One of the bands, the upper one and the smaller of the two, is fixed to the symphysis of the pubes; and the lower band, which forms the lower margin of the aponeurosis, being stretched between the anterior superior spine of the ilium and the pubes is named

Poupart's ligament, or the femoral arch. This latter tendinous band has considerable breadth. It is fixed at the inner end to the spine of the pubes, and, for some space outside that process of the bone, to the pectineal ridge. In consequence of the position of the pectineal ridge at the back part of the bone, the ligament is tucked backwards and its upper surface affords space for the attachment of the other broad muscles, at the same time that it supports the spermatic cord. Poupart's ligament does not lie in a straight line between its two fixed points; it curves downwards, and with the curved border the fascia lata is connected. It is owing to the last-mentioned fact that the so-named ligament, together with the rest of the aponeurosis of the external oblique, is influenced by the position of the thigh, being relaxed when the limb is bent and the converse. Moreover, the change of the position of the limb exercises a corresponding influence on the state of the other structures connected with Poupart's ligament.

The interval left by the separation of the fibres of the aponeurosis above referred to, is named the *external abdominal ring*, and the two bands by which it is bounded, are known as its *pillars* or *columns*. The space is triangular in shape, its base being the crista of the pubes, while the apex is at the point of separation of the two columns. The size of the ring varies considerably in different bodies;—in one case its sides will be found closely applied to the spermatic cord: while, in another, on the contrary, the space is so considerable as to be an obvious source of weakness to the abdominal parietes. It is usually smaller in the female than in the male body.

Fig. 497.

The aponeurosis of the external oblique muscle and the fascia lata.—1. The internal pillar of the abdominal ring. 2. The external pillar of same (Poupart's ligament). 3. Transverse fibres of the aponeurosis. 4. Pubic part of the fascia lata. 5. The spermatic cord. 6. The long saphenous vein. 7. Fascia lata.

Between the pillars of the abdominal ring is stretched a thin fascia, named, from that circumstance, "intercolumnar;" and a thin diaphanous membrane prolonged from the edges of the opening affords a covering (fascia spermatica) to the spermatic cord and the tunica vaginalis testis. The cord passes through the ring over its outer pillar.

Internal oblique muscle (vol. i. p. 416).—After removing the aponeurosis of the external oblique, this muscle is laid bare (fig. 498). The lower fibres are thin and often of a pale colour. Immediately above Poupart's ligament the outer part is muscular, the inner part tendinous. The spermatic cord, when about to escape at the external abdominal

ring, passes beneath the fleshy part of the muscle. The fibres in this situation varying considerably in direction from those of the rest of the muscle, pass inwards from Poupart's ligament at first nearly parallel with that structure; and, becoming tendinous, they join with the tendon of the transversalis.

Fig. 498.

The aponeurosis of the external oblique muscle having been divided and turned down, the internal oblique is brought into view with the spermatic cord escaping beneath its lower edge. —1. Aponeurosis of the external oblique. 1′. Lower part of same turned down. 2. Internal oblique muscle. 3. Spermatic cord. 4. Saphenous vein.

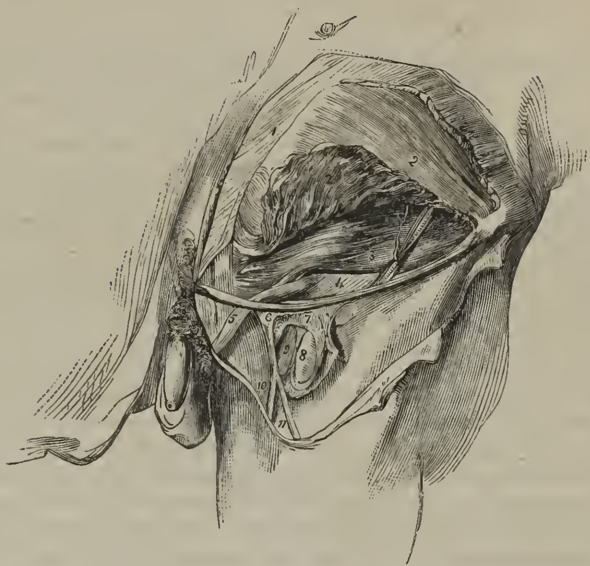
Transversalis muscle.—This muscle (see p. 417) does not, in general, extend down as far as the internal oblique (fig. 499); so that the latter being removed, an interval is observable between the edge of the transversalis and Poupart's ligament, in which the transversalis fascia comes into view; and in which the spermatic cord is seen after having penetrated that fascia. The lower edge of the muscle is commonly close above the opening for the cord in the subjacent membrane, while the tendon curves to its inner side. So that the margin of the muscle with its tendon has a semicircular direction with respect to the aperture.

The tendinous fibres in which the fleshy part of the two preceding muscles end, are connected together so as to form one layer, which is named the "conjoined tendon of the internal oblique and transverse muscle." This tendon is fixed to the crest of the pubes in front of the rectus muscle, and likewise to the pectineal ridge. It is thus behind the external abdominal ring, and serves to strengthen the wall of the abdomen where it is weakened by the presence of that opening.

A band of tendinous fibres (fig. 499) directed upwards and inwards over the conjoined tendon in a triangular form gives additional strength

to the abdominal wall in the same situation, but the fibres of this structure are often very indistinct.

Fig. 499.



After the removal of the lower part of the external oblique (with the exception of a small slip including Poupart's ligament), the lower portion of the internal oblique was raised, and thereby the transversalis muscle and fascia have been brought into view. The femoral artery and vein are seen to a small extent, the fascia lata having been turned aside and the sheath of the blood-vessels laid open.—1. External oblique muscle. 2. Internal oblique. 2′. Part of same turned up. 3. Transversalis muscle. Upon the last-named muscle is seen a branch of the circumflex iliac artery, with its companion veins; and some ascending tendinous fibres are seen over the conjoined tendon of the two last-named muscles. 4. Transversalis fascia. 5. Spermatic cord covered with the infundibuliform fascia from preceding. 6. Upper angle of the iliac part of fascia lata. 7. The sheath of the femoral vessels. 8. Femoral artery. 9. Femoral vein. 10. Saphenous vein. 11. A vein joining it.

Where the spermatic cord is in apposition with the preceding muscle, the cremaster muscle of the testis descends over it. The fibres which compose this muscle are, from their colour, more easily distinguished than the other investments of the cord; and this is especially the case in robust persons or when they are hypertrophied, as sometimes happens in cases of long-standing hernia. The outer part of the cremaster is much larger than the portion connected with the pubes; indeed, it sometimes happens that the latter is not to be discerned even with most careful dissection (see vol. ii. p. 542).

When observed in different bodies the lower part of the internal oblique and transverse muscles will be found to present some differences in their physical characters as well as in the manner in which they are disposed with respect to the spermatic cord. Thus:—

a. The transversalis, in some cases, is attached to but a small part of Poupart's ligament, and leaves, therefore, a larger part of the abdominal wall without its support. On the other hand, that muscle may be found to extend so low down as to cover the internal abdominal ring together with the spermatic cord, for a

short space. Not unfrequently the fleshy fibres of the two muscles are blended together as well as their tendons.

b. Cases occasionally occur in which the spermatic cord, instead of escaping beneath the margin of the internal oblique, is found to pass through the muscle, so that some muscular fibres are below as well as above it. And examples of the transversalis being penetrated by that structure in the same manner are recorded.*

c. In his latest account of the structure of these parts Sir A. Cooper described the lower edge of the transversalis as curved all round the internal ring and the spermatic cord. "But the lower edge of the transversalis has a very peculiar insertion, which I have hinted at in my work on hernia. It begins to be fixed in Poupart's ligament, almost immediately below the commencement of the internal ring, and it continues to be inserted behind the spermatic cord into Poupart's ligament as far as the attachment of the rectus."† With this disposition of its fibres, the muscle would, in the opinion of the last-cited authority, have the effect of a sphincter, in closing the internal ring, and would thus tend to prevent the occurrence of hernia. But the principal object with which the attention of surgeons has been fixed on the muscles in this situation, is in order to account for the active strangulation of hernial protrusions at the internal abdominal ring, and in the inguinal canal.

Fascia transversalis.—This membrane is described as part of the general lining of the abdominal walls at p. 302, vol. i. Closely connected with the transversalis muscle by means of the cellular membrane interposed between the fleshy fibres of the muscle, it is united below to the posterior edge of Poupart's ligament, there joining with the fascia iliaca; and on the inner side it blends with the conjoined tendon of the internal oblique and transversalis muscles, as well as with the tendon of the rectus. The fascia possesses very different degrees of density in different cases; in some being little more than a loose cellular texture, while in others it is so resistant at the groin,—towards which part it increases in thickness, and especially at the inner side of the internal abdominal ring—that it is calculated to afford material assistance to the muscles in supporting the viscera. By an oval opening in this membrane the spermatic cord (or the round ligament of the womb) begins its course through the abdominal parietes. This opening, named the *internal abdominal ring*, is opposite the middle of Poupart's ligament and usually close above that structure, but occasionally at a distance of three or four lines from it. Its size varies a good deal in different persons, and is considerably greater in the male than the female. From the edge of the ring a thin funnel-shaped elongation (infundibuliform fascia; fascia spermatica interna, Cooper), is continued over the vessels of the spermatic cord.

Epigastric artery.—The position of this vessel is one of the most important points in the anatomy of the inguinal region, from the close connexion which it has with the different forms of inguinal hernia and with the femoral hernia. Accompanied by two veins (in some instances by only one) the vessel ascends under cover of the fascia last described obliquely to the rectus muscle, behind which it then proceeds to its ultimate distribution (see p. 619). In this course the

* Recherches Anatomiques sur les Hernies, &c., par J. Cloquet, pp. 18 and 23, Paris, 1817. Inguinal and Femoral Herniæ, by G. J. Guthrie, plate 1, London, 1833.

† Observations on the Structure and Diseases of the Testis, second edition, p. 36. Ed. by Bransby B. Cooper, F.R.S. London, 1841.

artery runs along the inner side of the internal abdominal ring—close to the edge of the aperture (fig. 501), or at a short interval from it. The vessels of the spermatic cord are therefore near to the epigastric artery; and the vas deferens, in turning from the ring into the pelvis, may be said to hook round it.

The Inguinal Canal.—This, the channel by which the spermatic cord passes through the abdominal muscles to the testis, begins at the internal abdominal ring, and ends at the external one. It is oblique in its direction, being parallel with and immediately above the inner half of Poupart's ligament; and it measures two inches in length. In front, the canal is bounded by the aponeurosis of the external oblique muscle in its whole length, and at the outer end by the fleshy part of the internal oblique also; behind it is the fascia transversalis, together with, towards the inner end, the conjoined tendon of the two deeper abdominal muscles. Below, the canal is supported by the broad surface of Poupart's ligament, which separates it from the sheath of the large blood-vessels descending to the thigh, and from the femoral canal at the inner side of those vessels.

The spermatic cord, which occupies the inguinal canal, is composed of the arteries, veins, lymphatics, nerves, and excretory duct (vas deferens) of the testis, together with a quantity of loose cellular membrane mixed up with those parts. The direction of the vessels just enumerated requires notice. The artery and vein incline outwards from the lumbar part of the vertebral column to reach the internal abdominal ring, where, after being joined by the vas deferens as it emerges from the pelvis, they change their course, inclining inwards along the inguinal canal; at the end of which they become vertical. There are thus repeated alterations in the direction of the vessels; and while at the beginning and ending all are close to the middle line of the body, they are considerably removed from that point where they come together to emerge from the abdominal cavity.

The coverings given from the constituent parts of the abdominal wall to the spermatic cord and the testis, namely, the cremasteric muscular fibres, with the two layers of fascia between which those fibres are placed (the infundibuliform and spermatic fasciæ), are very thin in their natural state; but they may be readily distinguished in a surgical operation from the investing superficial fascia, by their comparative density and the absence of fat.

In order to examine the *peritoneum* at the groin it will be best to divide that membrane with the abdominal muscles by two incisions drawn from the umbilicus—one to the ilium, the other to the pubes. The flap thus formed being held somewhat outwards, and kept tense, a favourable view will be obtained of the two fossæ (*inguinal fossæ or pouches*) with the intervening crescentic fold. This fold is formed by the cord remaining from the obliterated umbilical artery, which being shorter than the outer surface of the serous sac, projects it inwards; and as the length of the cord differs in different cases, so likewise does the size and prominence of the peritoneal fold vary accordingly.

The lowest part of the outer fossa will be generally found opposite to the entrance into the internal abdominal ring and the femoral ring,

while the inner one corresponds with the situation of the external abdominal ring. But the cord representing the umbilical artery, which, it has been stated, causes the projection of the serous membrane into a fold, does not uniformly occupy the same position in all cases. Most frequently it is separated by an interval from the epigastric artery (fig. 501), while in some cases it is immediately behind that vessel. There is necessarily a corresponding variation in the extent of the external peritoneal fossa. This fact will find its practical application when the internal form of inguinal hernia is under consideration.

Between the peritoneum and the fascia lining the abdominal muscles is a connecting layer of cellular structure, named the *subserous cellular membrane*. A considerable quantity of fat is in some cases found in this membrane.

The relative position of some of the parts above referred to may be here conveniently stated, by means of measurements, made by Sir A. Cooper, and adopted after examination by J. Cloquet. But as the distance between given parts varies in different cases, the following measurements must only be regarded as a general average:—

	Male.	Female.
From the symphysis of the pubes to the anter. supr. spine of the ilium	$5\frac{1}{2}$ inches.	6 inches.
From the same point to the spine of the pubes	$1\frac{1}{8}$ "	$1\frac{3}{8}$ "
" to the inner part of the external abdominal ring	$0\frac{7}{8}$ "	1 "
" to the inner edge of the internal abdominal ring	3 "	$3\frac{1}{4}$ "
" to the epigastric artery on the inner side of the internal abdominal ring	$2\frac{3}{4}$ "	$2\frac{7}{8}$ "

From the preceding account of the structure of the abdominal wall at the groin, it will be inferred that the defence against the protrusion of the viscera from the cavity is here weaker than at other parts. The external oblique muscle and the fascia transversalis are perforated, while the two intervening muscles are thinner than elsewhere, and more or less defective. To this it must be added that the viscera are impelled towards the same part of the abdomen by the contraction of the diaphragm and the other abdominal muscles, which occurs in the production of efforts to overcome resistance; and these are the circumstances under which protrusions actually take place.

INGUINAL HERNIÆ.

The protrusions of the viscera or herniæ, which occur in the course of the inguinal canal, are named "inguinal." Of this form of the disease two varieties are recognised: and they are distinguished according to the part of the canal which they first enter into, as well as by the position they bear with respect to the epigastric artery. Thus, when the hernia takes the course of the inguinal canal from its commencement, it is named *oblique*, because of the direction of the canal, or *external*, from the position its neck bears with respect to the

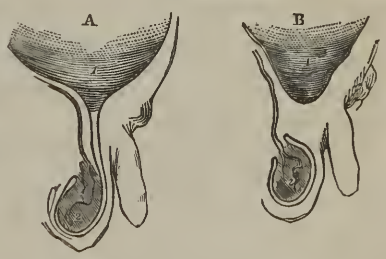
epigastric artery. On the other hand, when the protruded part, without following the length of the canal, is forced at once through its termination, *i. e.*, through the external abdominal ring, the hernia is named from its course *direct*, or, from its relation to the epigastric artery, *internal*. In these, the two principal varieties of inguinal hernia, there are some modifications which will be adverted to in the special notice of each.

Oblique inguinal hernia.—In the common form of this hernia the protruded viscus carries before it a covering of peritoneum (the *sac* of the hernia), derived from the outer fossa of that serous membrane; and in passing along the inguinal canal to the scrotum, it is successively clothed with the coverings given to the spermatic vessels from the abdominal parietes. The hernia and its sac lie directly in front of the vessels of the spermatic cord, fig. 503 (the intestines and the peritoneum having the same position relatively to those vessels in the abdomen); but when the disease is of long standing the vessels may be found to be separated one from the other, and pressed more or less towards the side or even the fore part of the sac under the influence of the weight of the tumour. The hernia does not extend below the testis even when it attains large size. That it does not is, doubtless, owing to the intimate connexion which the coverings of the cord have with the tunica vaginalis testis.

When the hernia does not extend beyond the inguinal canal, it is distinguished by the name *bubonocele;* and when it reaches the scrotum, it is commonly named from that circumstance *scrotal* hernia.

There are two other varieties of oblique inguinal hernia, in which the peculiarity depends on the condition of the process of peritoneum that accompanies the testis when this organ is moved from the abdomen. In ordinary circumstances, the part of the peritoneum connected immediately with the testis, becomes separated from the general cavity of that serous membrane by the obliteration of the intervening canal, fig. 500, B; and the hernial protrusion occurring after such obliteration has been completed, carries with it a distinct serous investment —the sac. But if the hernia should be formed before the process of obliteration is begun (fig. 500, A), the protruded part is then received into the cavity of the tunica vaginalis testis, which serves in the place of its sac. In this case the hernia is named *congenital* (hernia tunicæ vaginalis—Cooper). It is thus designated, because the condition necessary for its formation usually exists only about the time of birth; but the same variety of the complaint is occasionally found to be first formed in the adult, obviously in consequence of the tunica vaginalis remaining unclosed,

Fig. 500.



Plans intended to represent a small part of the peritoneum and the tunica vaginalis testis. In the first, A, the serous investment of the testis is seen to be an elongation from the peritoneum; while in the second, B, the two membranes are shown distinct one from the other.—1. The peritoneal cavity. 2. The testis.

—still continuous with the peritoneum. The congenital hernia, should it reach the scrotum, passes below the testis; and this organ being imbedded in the protruded viscus, a careful examination is necessary, in order to detect its position. This peculiarity serves to distinguish the congenital from the ordinary form of the disease.

To the second variety of inguinal hernia, in which the distinguishing character depends on the state of the tunica vaginalis testis, the name "infantile" has been applied (Hey). The hernia in this case is covered with a distinct sac, the peculiarity consisting in the circumstance of the rupture with its sac being invested by the upper end of the tunica vaginalis. The relative position of the two serous membranes (the hernial sac and the tunica vaginalis) may be accounted for by supposing the hernia to descend when the process of peritoneum, which accompanies the testis from the abdomen, has been merely closed at the upper end, but not obliterated for any length. As the tunica vaginalis at this period extends upwards to the wall of the abdomen, the hernia, in its descent, soon meets that membrane and becomes invested by it. The exact mode of the investment has not yet been clearly made out by dissection. It may be that the hernia passes behind the upper end of the large serous tunic of the testis which then laps round the sac from before, or that the tunica vaginalis is inverted from above so as to receive the hernia in a depression. But the fact most material for the surgeon is fully ascertained, namely, that during an operation in such a case the hernial sac is met with only after another serous bag (the tunica vaginalis testis) has been divided. The peculiarity here described has been repeatedly found present in the recently formed hernia of grown persons. The term infantile, therefore, like congenital, has reference to the condition of certain parts rather than to the period of life at which the disease is first formed.

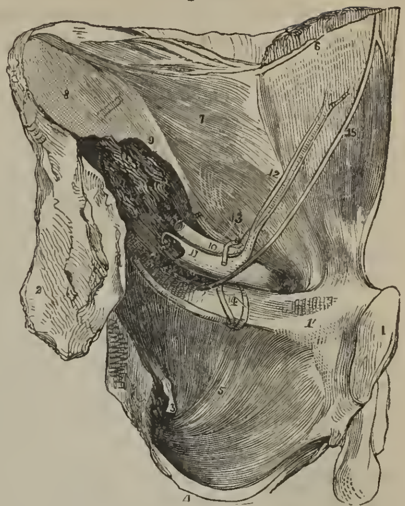
In the female oblique inguinal hernia follows the course of the round ligament of the uterus along the inguinal canal, in the same manner as in the male it follows the spermatic cord. After escaping from the external abdominal ring, the hernia lodges in the labia pudendi. The coverings are the same as those in the male body, with the exception of the cremaster, which does not exist in the female; but it occasionally happens that some fibres of the internal oblique muscle are drawn down over this hernia in loops, so as to have the appearance of a cremaster (Cloquet).

A strictly congenital inguinal hernia may occur in the female, the protruded parts being received into the little diverticulum of the peritoneum (canal of Nuck), which sometimes extends into the inguinal canal with the round ligament. But as this process of the peritoneum, in such circumstances, would probably not differ in any respect from the ordinary sac, there are no means of distinguishing a congenital hernia in the female body.

Direct inguinal hernia (internal: ventro-inguinal). Instead of following the whole course of the inguinal canal, in the manner of the hernia above described, the viscus in this case is protruded from the abdomen to the groin directly through the lower end of the canal, at

the external abdominal ring; and at this point the two forms of hernia, if they coexisted, would come together. At the part of the abdominal wall through which the direct inguinal hernia finds its way, there is recognised on its posterior aspect a triangular interval, the sides of which are formed by the epigastric artery and the margin of the rectus muscle, the base by Poupart's ligament (fig. 501). It is commonly named the triangle of Hesselbach. Through this space the hernia is protruded, carrying before it a sac from the internal fossa of the peritoneum; and it is in general forced onwards directly into the external abdominal ring.

Fig. 501.



A portion of the wall of the abdomen and of the pelvis is here seen on the posterior aspect, the os innominatum of the left side with the soft parts connected with it having been removed from the rest of the body.—1. Symphysis of pubes. 1'. Horizontal branch of same. 2. Irregular surface of the ilium which has been separated from the sacrum. 3. Spine of ischium. 4. Tuberosity of same. 5. Obturator internus. 6. Rectus, covered with an elongation from 7. Fascia transversalis. 8. Fascia iliaca covering iliacus muscle. 9. Psoas magnus cut. 10. Iliac artery. 11. Iliac vein. 12. Epigastric artery and its two accompanying veins. 13. Vessels of spermatic cord, entering the abdominal wall at the internal ring. The ring was in this case of small size. 14. Two obturator veins. 15. The obliterated umbilical artery. This cord, it will be remembered, is not naturally in contact with the abdominal parietes in this situation.

The coverings of this hernia, taking them in the order in which they are successively applied to the protruded viscus, are the following: — The peritoneal sac and the cellular membrane which adheres to it, the fascia transversalis, the tendon common to the internal oblique and transverse muscles (fig. 502), and the intercolumnar (external spermatic) fascia derived from the margin of the external abdominal ring, together with the superficial fascia and the integuments.

With respect to one of the structures enumerated, namely, the common tendon of the two deeper muscles, considerable variety exists as to its disposition in different cases. In place of being covered by that tendon, (which my own observations lead me to regard as the most frequent arrangement,) the hernia may be found to pass through an opening in its fibres, or to escape beneath it (fig. 503). Cremasteric muscular fibres are met with (rarely, however) upon this hernia.

The spermatic cord is commonly placed behind the outer part of the direct inguinal hernia, especially at the external abdominal ring (figs. 502-3). It is here that the hernia and the cord in most cases first come together; and their relative position results from the points at which they respectively pass through the ring, the former being upon the crista of the pubes, while the latter drops over the outer pillar of the opening. The hernial sac is not, however, in this case

(as the sac of the external form of the disease is) in contact with the vessels of the cord. The investments given from the fascia transversalis to those vessels and to the hernia respectively, are interposed.

Fig. 502.

Fig. 503.

Fig. 502. A direct inguinal hernia on the left side, covered by the conjoined tendon of the internal oblique and transverse muscles.—1. Aponeurosis of the external oblique. 2. Internal oblique turned up. 3. Transversalis muscle. 4. Fascia transversalis. 5. Spermatic cord. 6. The hernia. N.B. A small part of the epigastric artery is seen through an opening made in the transversalis fascia.

Fig. 503. A small oblique inguinal hernia, and a direct one, are seen on the right side. A little of the epigastric artery has been laid bare, by dividing the fascia transversalis immediately over it.—1. Tendon of the external oblique. 2. Internal oblique turned up. 3. Transversalis. 4. Its tendon (the epigastric artery is shown below this number). 5. The spermatic cord (its vessels separated). 6. A bubonocele. 7. Direct hernia protruded beneath the conjoined tendon of the two deeper muscles, and covered by an elongation from the fascia transversalis.

But the point at which the internal inguinal hernia passes through the triangular space above described as marked on the posterior aspect of the abdominal wall, is subject to some variation. Instead of pushing directly through the external abdominal ring (the most frequent position), the hernia occasionally enters the inguinal canal nearer to the epigastric artery, and passing through a portion of the canal to reach the external ring, has therefore a certain degree of obliquity. This change in position may coincide with a change of the peritoneal fossa, which furnishes the hernial sac—a change, namely, from the internal fossa to the external one. The alteration of the fossa does not however in all cases coincide with a change in the position of the hernia; for the cord remaining from the obliteration of the umbilical artery, (which it is that separates the fossæ,) instead of crossing behind the triangle of Hesselbach so as to leave room at either side of it for a hernia to penetrate that space, is, it has been already stated, sometimes directly behind the epigastric artery:—indeed, according to the observations of Cloquet, it is most frequently in this position;* and when the cord in question is so placed, the hernia, whatever may be its position in

* Recherches, &c., p. 39, note.

the triangle of Hesselbach, can occupy only the internal peritoneal fossa. The inference, however, most important in a practical or surgical point of view, to be drawn from the varying position of the neck of the internal hernia, has reference not to the cord just alluded to, but to the epigastric artery—*i. e.* to the greater or less distance of the neck of the sac from that vessel.

The investments of the internal hernia are likewise liable to be influenced by the position at which it penetrates the abdominal wall. It is in all likelihood when the protrusion occurs outside the ordinary situation, that the hernia escapes beneath the conjoined tendon of the two deeper muscles. It is, moreover, under the same circumstances that hernia is more directly in front of the spermatic cord, and that the cremasteric fibres are among its investments.*

The internal inguinal hernia is very rarely met with in *the female.* In the single example of the disease that I have had an opportunity of observing, as well as in the cases (a very small number) which I have found recorded in books, the hernia, though not inconsiderable in size, was still covered with the tendon of the external oblique muscle.†

Distinctive diagnosis of oblique and direct inguinal herniæ.—The following circumstances, which are brought together from the facts detailed in the preceding pages, or are inferences from those facts, will serve to distinguish the two forms of the disease one from the other. The first-named hernia, when recently formed, is elongated and narrow at its upper part, being restrained by the tendon of the external oblique muscle. It is, however, attended with a degree of fulness in the inguinal canal, as well as tenderness, upon pressure being made over the canal. After passing through the external abdominal ring, it is observed to be directly in front of the spermatic cord. The direct hernia, when of small size, is globular; it is protruded more immediately over the pubes; causes no fulness or tenderness in the canal; and the spermatic cord is usually behind its outer side. But the distinction between the two herniæ admits of being made only when the disease is recent and the tumour moderate in size; for when oblique inguinal hernia is of long standing, and has attained considerable size, the obliquity of the inguinal canal no longer remains,—the internal ring being enlarged, and brought inwards opposite the external one,—while at the same time the epigastric artery, borne inwards by the hernia, curves along the inner side of the sac. Under this change, the oblique hernia assumes the appearance of one primarily direct.

* Mr. Ellis informs me, that in dissecting cases of internal hernia, he has repeatedly found fibres of the cremaster spread over it, when the tumour was nearer than usual to the epigastric artery, and only in this event.

† See "Treatise on Ruptures," by Mr. Lawrence, 4th edit. p. 213, and an essay by M. Velpeau in "Annales de Chirurgie Française et étrangère," tom. i. p. 352.

M. Velpeau, in the essay just referred to, proposes to recognise three varieties of internal hernia, viz., 1, the ordinary form, which passes straight through the external abdominal ring; 2, an outer oblique variety, which passes through a part of the inguinal canal; and, 3, an inner oblique one, which, entering the abdominal wall close to the edge of the rectus muscle, is directed outwards in order to reach the opening in the external oblique muscle. The first two forms adverted to by M. Velpeau have been described in the text. With respect to the third variety or class sought to be introduced by that surgeon, it should be observed that he seems to have been led to propose it by the observation of a single case—an example of internal hernia in the female.

Operations for the relief of inguinal hernia.—This account of the disposition of the parts connected with the different forms of inguinal hernia, may be concluded by a brief statement of the application of the anatomical facts in practical surgery, either in simply replacing the hernial protrusion, or in the operation required to attain that object when the hernia is otherwise irreducible. In the efforts to effect the replacement of the protruded parts (the taxis), it is to be borne in mind that the abdominal muscles, which in most cases are the sole obstacle to the attainment of that end, become relaxed, to some extent, by flexing the thigh and inclining the trunk forwards. The direction, too, which the protruded part follows through the abdominal walls, ought to influence the direction given to the pressure required in restoring it.

When the operation required to set free the constriction which prevents the restoration of the protruded viscus to the abdomen is undertaken, the parts covering the hernia or a portion of it at the upper end, are to be divided, so as to allow the introduction of a knife beneath the "stricture;" and this (the stricture) will be found at the external ring, or, more frequently, at the internal one. To accomplish the object, the tendon of the external oblique is to be laid bare by an incision, beginning somewhat above the upper end of the hernia, and extending downwards below the external ring. If, on examination, the stricture should be ascertained to be at the last-named opening. the division of a few fibres of its circumference will allow a sufficient dilatation for the replacement of the hernia; but if, as generally happens, the seat of the stricture should prove to be higher up,—in the inguinal canal or at the internal ring, the aponeurosis of the external oblique is to be cut through over the canal, and the lower edge of the internal muscles, one of which commonly constitutes the stricture, is then to be divided on a director insinuated beneath them.

In the operation indicated in the last paragraph, the sac of the hernia is supposed to be left unopened,—the course which it is best to adopt when the stricture is external to that membrane. Occasionally, however, it happens that the sac itself is the cause of the constriction. When this is the case, or when from some other reason the surgeon is unable, after such an operation as that above noticed, to replace the hernia, it becomes necessary to lay the sac open, in order to divide the constriction at its neck. When the incision required in the last-mentioned step of the operation is being made, the epigastric artery is not to be overlooked. From the position that vessel holds, with respect to the oblique and direct forms of hernia respectively, it necessarily follows that an incision outwards through the neck of the sac, in the former variety of the disease, and inwards in the latter, would be free from risk on account of the artery (fig. 503); but, inasmuch as the oblique hernia is liable, in time, to assume the appearance of one primarily direct (see last page), and a want of certainty as to the diagnosis must, on this account, exist in certain cases,—as, moreover, it is advantageous to pursue one course which will be applicable in every case,—the rule generally adopted by surgeons, in all operations for inguinal herniæ, is to carry the incision through the neck of the sac directly upwards from its middle.

OF THE PARTS CONCERNED IN FEMORAL HERNIA.

The hernia distinguished as "femoral" leaves the abdomen at the groin, under the margin of the broad abdominal muscles, and upon the horizontal branch of the pubes, immediately at the inner side of the large femoral blood-vessels. After passing downwards, for a very short space, about an inch or less, the hernia turns forwards to the fore part of the thigh at the saphenous opening in the fascia lata ; and when it has reached this point the swelling may be felt and seen.

The muscles of the abdomen, beneath the edge of which the femoral hernia escapes, are represented by the aponeurotic band of the external oblique muscle, which is commonly known as Poupart's ligament, but which, in connexion with the femoral hernia, is named the *femoral* or *crural arch.* Extending from the anterior superior spine of the ilium to the pubes, this band widens at its inner end, and, inclining or folding backwards, is fixed to a part of the pectineal line, as well as to the spine of the pubic bone. The small triangular portion attached to the pectineal line (fig. 504) is known as Gimbernat's ligament (Hey). The outer edge of this part is concave and sharp; with other structures, to be presently described, it forms the inner boundary of the aperture through which the hernia descends. The breadth and strength of Gimbernat's ligament vary in different bodies, and with its breadth varies the size of the opening which receives the hernia.

Fig. 504.

The innominate bone of the left side with, 1, the femoral or crural arch; 2, Gimbernat's ligament.

The space comprised between the femoral arch and the excavated margin of the pelvis is occupied by the conjoined psoas and iliacus, with the anterior crural nerve between those muscles, and the external iliac artery and vein at their inner side. Upon these structures the fascia which lines the abdomen is so arranged as to close the cavity against the escape of any part of the viscera, except at the inner side of the blood-vessels. But the arrangement of the parts situated thus deeply (towards the cavity of the abdomen) will be most conveniently entered upon after those nearer to the surface shall have been examined. To this examination we now proceed.

The general disposition of the *superficial fascia* met with on removing the common integument from the groin has been described (vol. i. p. 307). In connexion with the present subject, it will be enough to mention the following facts. The deeper layer of this structure adheres closely to the edge of the saphenous opening, and the careful removal of it is necessary in order adequately to display that aperture. Where it masks the saphenous opening, the deep layer of the superficial fascia

supports some lymphatic glands, the efferent vessels of which pass through it; and the small portion of the membrane so perforated is named the *cribriform fascia.* The superficial and the deep fasciæ adhere together along the fold of the groin likewise, and this connexion between the two membranes serves the purpose, at least, of drawing the integument the more evenly into the fold of the groin, when the limb is bent at the hip-joint.

By Scarpa the deep layer of the superficial fascia which covers the abdomen was described as an emanation from the fascia lata, extended upwards over the external oblique muscle.* But different modes of viewing the continuity of such structures depend very much on the manner of conducting the dissection. In the present case, for example, the fascia may be said to proceed from above or from below, according as the parts are dissected from the abdomen downwards or from the thigh upwards. Such difference, however, is no more than a verbal one, the material fact being merely that the two membranes are connected together along the groin.

The separation of the *fascia lata* into two parts at the saphenous opening, and the position and connexions of each part, having been described in detail (p. 308), only a few points in the arrangement of this membrane will be noticed in this place. At the lower end of the saphenous opening the iliac division of the fascia is continuous with the pubic by a well-defined curved margin, immediately above which the saphenous vein ends; above the opening a pointed cornu (falciform process—Burns)† of the same portion of the fascia (fig. 497), extending inwards in connexion with the femoral arch, reaches Gimbernat's ligament; and in the interval between the two points now referred to (*i. e.*, from the upper to the lower end of the saphenous opening), the iliac layer of the fascia lata blends with the subjacent sheath of the femoral vessels as well as with the superficial fascia. The pubic part of the fascia covers the pectineus muscle, and is attached to the pectineal ridge of the pubes. Immediately below the femoral arch the iliac and pubic portions lie, one before, the other behind, the femoral blood-vessels and the sheath of these. They occupy the same position with respect to the femoral hernia.

For an account of the superficial arteries and veins which ramify in the integument in the neighbourhood of the groin, see vol. i. p. 623; vol. ii. p. 25.

The anterior or iliac part of the fascia lata being turned aside, the *sheath of the femoral vessels* will be in view, fig. 499. The sheath is divided by septa, so that each vessel is lodged in a separate compartment, and the vein is separated by a thin partition from the artery on one side and from the short canal for the lymphatics on the other side. Along the thigh the sheath is filled by the artery and vein, but behind the femoral arch it is widened at the inner side. Here it is perforated for lymphatic vessels, and on this account it is said to be

* A Treatise on Hernia, translated by Wishart, p. 247.

† Edinb. Med. and Surg. Journal, vol. ii. p. 263, and fig. 2.

In the first edition of Hey's Practical Observations in Surgery, the upper end of this process of the fascia was named the "femoral ligament;" and since then several anatomists have distinguished the same part as "Hey's ligament." But Mr. Hey dropped the designation in the subsequent editions of the same work, and there seems no good reason for continuing it. Compare the original edition (1803), p. 151, and plate 4, with the third edition (1814), p. 147, and plates 4, 5, and 6.

"cribriform."* This inner, wider part of the sheath it is that receives the femoral hernia (fig. 505); and in connexion with the anatomical description of that disease, it is designated the femoral canal. At its

Fig. 505.

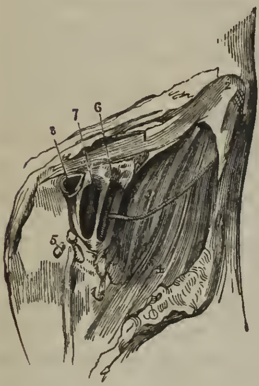


Fig. 506.

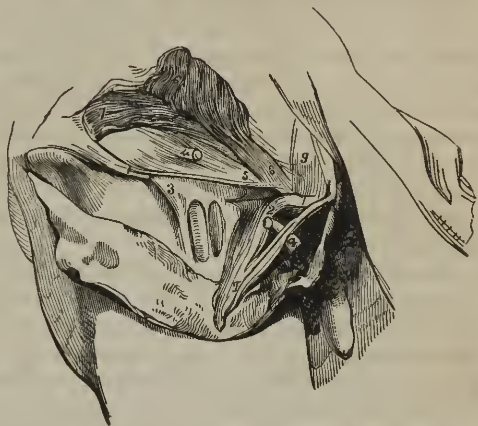


Fig. 505. The femoral vessels of the left side, with their sheath laid open, and a small hernia displayed.—1. The lower part of the external oblique muscle. 2. The anterior superior spine of the ilium. 3. Iliacus muscle. 4. Sartorius. 5. Pubic part of the fascia lata. 6. Femoral artery. 7. Femoral vein. 8. A small hernia.

Fig. 506. The groin of the right side dissected so as to display the deep femoral arch.—1. The outer part of the femoral arch. 1'. Part of the tendon of the external oblique muscle, including the femoral arch, and also the inner column of the external inguinal ring, projecting through which is seen a portion of the spermatic cord cut. 2. The femoral arch at its insertion into the spine of the pubes. The fibres outside the numeral are those of Gimbernat's ligament. 3 The outer part of the femoral sheath. 4. The spermatic cord, after having perforated the fascia transversalis. 5. The deep femoral arch—its inner end where it is fixed to the pubes. 6. Internal oblique muscle. 7. Transversalis. Beneath the lower edge of this muscle is seen the transversalis fascia, which continues into the femoral sheath under the deep femoral arch. 8. Conjoined tendon of the internal oblique and transversalis muscles. 9. A band of tendinous fibres directed upwards behind the external abdominal ring.

upper end the sheath of the vessels is continuous with the lining membrane of the abdomen—with the fascia transversalis at its fore part (fig. 499, 506), with the fascia iliaca behind.

When the femoral artery is being removed, it will be found that a bundle of fibres (fig. 506), springing from its under surface outside the femoral vessels, extends across the fore part of the femoral sheath, and, widening at its inner end, is fixed to the pecten of the pubes behind Gimbernat's ligament. This tendinous band is known as the *deep femoral arch*. Connected with the same part of the pubes is the conjoined tendon of the internal oblique and transverse muscles (fig. 499). The tendon lies behind the attachment of the deep femoral arch (fig. 506). In many cases the last-named structure is not strongly marked; and it may be found to blend with the tendon

* The word 'cribriform' being applied to this part as well as to the layer of the superficial fascia stretched across the saphenous opening, the two structures are distinguished in the following manner:—the former is known as the cribriform portion of the sheath of the vessels, while to the latter is assigned the name of cribriform fascia.

of the muscles just referred to. Not unfrequently it is altogether wanting.

Attention now being directed to the internal surface of the abdomen (fig. 501):—When the peritoneum has been removed, it will be observed that the fasciæ lining the cavity form for the most part a barrier against the occurrence of hernia; for outside the iliac vessels the fascia iliaca and fascia transversalis are continuous one with the other behind the femoral arch. These fasciæ are, in fact, but parts of the same membrane to which different names are assigned for the convenience of description, just as distinctive names are applied to portions of the same artery. But where the iliac artery and vein occur, the arrangement of the fasciæ is different. The vessels rest upon the fascia iliaca; and the membranes, instead of joining at an angle as elsewhere, are continued into their sheath in the manner above described.*

The sheath is closely applied to the artery and vein, so that, in the natural or healthy state of the parts there is no space left for the formation of a hernia in the compartments which belong to those vessels; but at the inner side of the blood-vessels will be found a depression which is occupied but partially with the lymphatics. This is the femoral ring, the orifice of the femoral canal.

Femoral ring.—After the removal of the peritoneum, this opening is not at first distinctly discernible, being covered with the laminated cellular membrane (subserous) which intervenes between the peritoneum and the walls of the abdomen. That part of the membrane which covers the ring was found by M. Cloquet to possess in some cases considerable density; and, from being the only barrier in this situation between the abdomen and the top of the thigh, it was named by that observer the *crural septum* (septum crurale). But this structure is usually no more than loose cellular membrane, and it forms but a very slight partition. On clearing it away, the ring is displayed (fig. 501). It is a narrow opening, usually of sufficient size to admit the end of the fore finger; the size, however, varies in different cases, and it may be said to increase as the breadth of Gimbernat's ligament diminishes, and the converse. It is larger in the female than in the male body. On three sides the ring is bounded by very unyielding structures. In front are the femoral arches; behind is the horizontal branch of the pubes covered by the pectineus muscle and the pubic layer of the fascia lata; on the outer side lies the external iliac vein, but covered with its sheath; and on the inner side are several layers of fibrous structure connected with the pectineal line of the pubes—namely, Gimbernat's ligament, the deep femoral arch, and the conjoined tendon of the two deeper abdominal muscles, with the fascia transversalis (fig. 506). The last-mentioned structures—those bound-

* Some anatomists describe the sheath of the vessels as continued down from the membranes in the abdomen, while others regard it as an emanation from the fascia of the thigh, but continuous with the abdominal fasciæ. As this difference in the manner of viewing the structure in question does not alter the facts in any way, it is quite immaterial which of the modes of description is adopted. But it appears to me most natural to regard the sheath as a production of the fascia lata.

ing the ring at the inner side—present respectively a more or less sharp margin towards the opening.

Femoral canal.—From the femoral ring, which is its orifice, the canal continues downwards behind the iliac part of the fascia lata (its falciform process), in front of the pubic portion of the same membrane, and ends at the saphenous opening. It is about half an inch in length; but in its length the canal varies a little in different cases.

Blood-vessels.—Besides the femoral vein, the position of which has been already stated, the epigastric artery is closely connected with the ring, lying above its outer side. It not unfrequently happens that the obturator artery descends into the pelvis at the outer side of the same opening, or immediately behind it; and in some rare cases that vessel turns round the ring to its inner side. Moreover, an obturator vein occasionally has the same course; and small branches of the epigastric artery will be generally found ramifying on the posterior aspect of Gimbernat's ligament. In the male body, the spermatic vessels are separated from the canal only by the femoral arch.

To the foregoing account of the anatomical arrangement of the parts concerned in femoral hernia, may be added certain measurements, showing the distances of some of the most important from a given point. They are copied from the work of Sir A. Cooper:—*

	Male.	Female.
From the symphysis pubis to the anterior spine of the ilium	$5\frac{3}{4}$ inches.	6 inches.
From same point to the middle of the iliac vein .	$2\frac{5}{8}$ "	$2\frac{3}{4}$ "
" to the origin of the epigastric artery	3 "	$3\frac{1}{4}$ "
" to the middle of the lunated edge of the fascia lata	$3\frac{3}{4}$ "	$2\frac{3}{4}$ "
" to the middle of the femoral ring	$2\frac{1}{4}$ "	$2\frac{3}{8}$ "

Descent of the hernia.—When a femoral hernia is being formed, the protruded part is at first vertical in its course (fig. 505); but at the lower end of the canal, after the passage of about half an inch, it undergoes a change of direction, bending forward at the saphenous opening; and, as it increases in size, it ascends over the iliac part of the fascia lata and the femoral arch. The hernia thus turns round those structures, passing from behind them to their anterior surface. Within the canal the hernia is very small, being constricted by the unyielding structures which form that passage; but when it has passed beyond the saphenous opening, it enlarges in the loose cellular membrane of the groin; and, as the tumour increases, it extends outwards in the groin towards the spine of the iliac bone. Hence its greatest diameter is transverse.

Coverings of the hernia.—The sac which is pushed before the protruded viscus, is derived from the external fossa of the peritoneum; except, however, when the cord of the obliterated umbilical artery is placed outside its ordinary position, in which case the serous membrane furnishes the sac from its internal fossa (see page 584). After

* On Crural Hernia, p. 5.

the sac, the hernia carries before it the subserous cellular membrane (septum crurale of Cloquet), which covers the femoral ring, and likewise an elongation from the sheath of the femoral vessels. These two structures combined constitute a single very thin covering, known as the fascia propria of the hernia (Cooper). It sometimes happens that the hernia is protruded through an opening in the sheath, which therefore in that event does not contribute to form the fascia propria.

Diagnosis.—Passing over the general symptoms of abdominal herniæ and the means of forming the diagnosis between a hernia and several other diseases with which it is liable to be confounded,—subjects which fall within the province of treatises on practical surgery, —I shall limit the observations to be made in this place to the anatomical circumstances which characterize femoral hernia, and serve to distinguish it from the inguinal form of the complaint. When the inguinal hernia descends to the scrotum or to the labium pudendi, and when the femoral hernia extends some distance outwards in the groin, no error in diagnosis is likely to arise. It is only in distinguishing between a bubonocele and a femoral hernia of moderate size that a difficulty occurs. The position of the femoral hernia is, in most cases, characteristic. The tumour is upon the thigh, and a narrowed part, or neck, may be felt sinking into the thigh near its middle. Besides, the femoral arch is usually to be traced above this hernia, while that band is lower than the mass of a tumour lodged in the inguinal canal. At the same time, the latter tumour covers the femoral arch, and cannot, like a femoral hernia when it has turned over that cord, be withdrawn from it. Some assistance will be gained, in a doubtful case, from the greater facility with which the tumour emerging at the saphenous opening admits of being circumscribed, in comparison with the bubonocele, which is bound down by a more resistant structure—the aponeurosis of the external oblique muscle. Other practical applications of the foregoing anatomical observations come now to be considered.

The taxis.—During the efforts of the surgeon to replace the hernia, the thigh is to be flexed upon the abdomen and inclined inwards, with a view to relax the femoral arch; the tumour is, if necessary, to be withdrawn from over the arch, and the pressure on it is to be directed backwards into the thigh.

The operation.—The replacement of the hernia by the means just adverted to being found impracticable, the operation is undertaken with the view of dividing the femoral canal (or some part of it), thereby widening the space through which the protruding viscus is to be restored to the abdomen, or with the view of relieving strangulation when the restoration of the part is not possible or not desirable. Inasmuch as the manner of conducting the operation chiefly depends on the place at which the constricting structures are to be cut into, it will be convenient in the first instance to determine this point; and with this object we shall inquire into the practicability and safety of making incisions into the femoral canal at different points of its circumference. As the hernia rests upon the pelvis (the pubes), the posterior part of the canal may at once be excluded from consideration; so likewise

may its outer side, on account of the position of the femoral vein, and the outer part of its anterior boundary also, because of the presence of the epigastric artery in this direction. There remains only the inner boundary with the contiguous part of the anterior one, and through any point of this portion of the ring or canal an incision of the required extent (always a very short one) can be made without danger in nearly all cases. The sources of danger are only occasional; for the urinary bladder when largely distended, and the obturator artery when it turns over the femoral ring—a very unusual course—are the only parts at the inner side of the hernia liable to be injured; while the last-named vessel, when it follows the course just referred to, and in the male the spermatic cord, are the structures in peril when the anterior boundary of the canal is cut into towards the inner side of the hernia.

Returning now to the steps of the operation:—After it has been ascertained that the urinary bladder is not distended, the skin is to be divided by a single vertical incision made on the inner part of the tumour, and extending over the crural arch. When the subcutaneous fat (the thickness of which is very various in different persons) is cut through, a small blood-vessel or two are divided, and some lymphatic glands may be met with. The hemorrhage from the blood-vessels seldom requires any means to restrain it; but the glands, if enlarged, retard the operation in some degree. The fascia propria of the hernia, which succeeds to the subcutaneous fat, is distinguished by its membranous appearance and the absence of fat. It is very thin, and caution is required in cutting through it, as the peritoneal sac is immediately beneath: the two membranes are indeed in contact, except in certain cases to be presently noticed. A flat director is now to be insinuated between the hernial sac and the inner side of the femoral canal, space for the instrument being gained by pressing its smooth surface against the neck of the hernia. On the groove of the director so introduced, or under the guidance of the fore-finger of the left hand, if the use of the director should be dispensed with, the probe-pointed bistoury is passed through the canal, and the dense fibrous structure of which it consists is divided, the edge of the knife being turned upwards and inwards, or directly upwards. By the former plan of relieving the stricture, the parts divided are the following, viz., the falciform process of the fascia lata and the structures fixed to the pectineal line of the pubes, namely, Gimbernat's ligament, the inner end of the deep femoral arch, and, it may be, the tendon of the two deep abdominal muscles with the fascia transversalis; while if the incision be directed upwards, the falciform process of the fascia lata and the two femoral arches are divided. The opening being sufficiently dilated, the protruded part is restored to the abdomen as in the taxis.

But it may be found necessary to lay the hernial sac open in order to examine its contents, or in order to relieve the impediment to the return of the hernia, if that should happen to reside in the neck of the sac itself. In this case it will probably be required to add to the vertical incision already made through the integuments and cellular

membranes another, directed outwards over the tumour, and parallel with the femoral arch. Such additional incision is readily made, by passing the scalpel beneath the integument and fat, and cutting outwards after the skin has been pierced with the point of the knife. The sac being now opened, the hernia knife is used at the inner side of its neck, while the bowel is guarded with the left hand. During the restoration of the protruded parts, some advantage will be gained if the edges of the divided sac should be held down with a pair or two of forceps in the hands of an assistant.

In the foregoing observations, it has been stated that the fascia propria is in contact with the sac of the hernia, except in certain cases. The exception is afforded by the interposition of fat, and sometimes in considerable quantity. The adipose substance is deposited in the subserous cellular membrane; it has the peculiarity of resembling the fat lodged in the omentum, and it is occasionally studded with small cysts, containing a serous fluid. The hernia will be most readily found in such circumstances behind the inner part of the adventitious substance; which should be turned outwards from the inner side, or cut through.

THE PERINEUM AND ISCHIO-RECTAL REGION.

A connected view of the structures which occupy the outlet of the pelvis becomes necessary, in consequence of the important surgical operations occasionally performed on the genito-urinary organs and the rectum, which are contained in that part. In the examination of these structures, which it is proposed to make in this place, attention will be confined to the male body.

The pelvic bones, as they bound the outlet of the pelvis, are already sufficiently described (vol. i. p. 205). The anterior portion of the space, which is appropriated to the urethra and the penis, is named the *perineum*. This part is triangular, the sides being formed by the branches of the ischium and pubes meeting at the symphysis pubis, while a line extended between the two tuberosities of the ischia represents the base of the triangle. In well-formed bodies, the three sides of the space are equal in length; but cases occur in which, by the approximation of the ischiadic tuberosities, the base is narrowed; and, we may anticipate the practical application of the anatomical facts so far as to state here, that this circumstance exercises a material influence on the operation of lithotomy, inasmuch as the incisions required in that operation, instead of being oblique in their direction, must, in such circumstances, be made more nearly straight backwards.

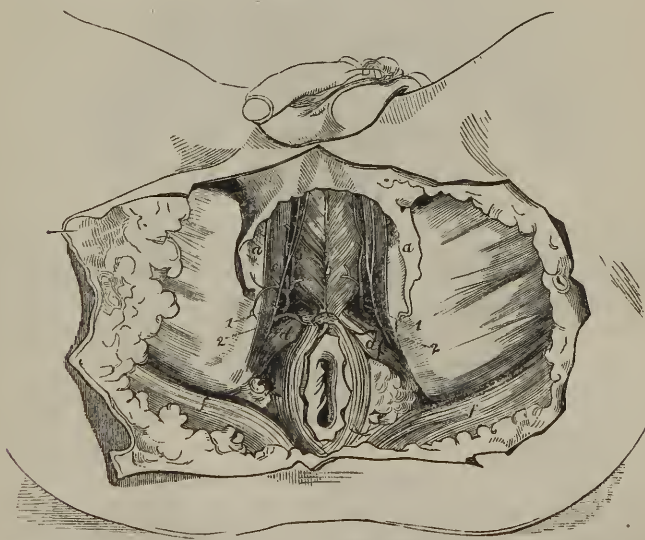
That portion of the outlet of the pelvis which lies behind the perineum may be named the ischio-rectal region. It contains the end of the rectum; and it is defined by the tuberosities of the ischium, the coccyx, and the great gluteal muscles. We shall now proceed to the detailed examination of the two parts thus mapped out.

The skin of *the perineum* continued from the scrotum, and partaking of the characters it has on that part, is dark-coloured, thin, and extensible, loosely connected with the subjacent textures, and in the male body studded with crisp hairs. Around the anus, it is thrown into

folds, which are necessary to allow the extension of the orifice of the bowel, during the passage of masses of fæcal matter; and along the middle of the perineum the median ridge or raphé of the scrotum is continued backwards to the anus. By this mark upon the skin, the large triangle in which is comprised the whole perineum, is subdivided into two equal parts. To one of these smaller spaces the operations usually performed for gaining access to the urinary bladder are for the most part restricted. The skin of the perineum is provided with numerous sebaceous follicles.

From the muscles of the perineum, the skin is separated by cellular membrane and fat, except in the neighbourhood of the anus, where the sphincter of the bowel is immediately in contact with the integument. The deeper part of the fatty cellular membrane,—the *superficial fascia* (see p. 304),—taking on a membranous appearance, has, in a great measure, the same arrangement and characters as the corresponding structure of the groin. With that membrane the perineal fascia is continuous in front through the scrotum, but at other points it is confined to the perineum, being fixed laterally to the branches of the ischium and the pubes (fig. 507), while it is continued posteriorly into the deep perineal fascia, beneath the sphincter ani and in front of the rectum. It is in consequence of these connexions of the superficial fascia of the perineum, that abscesses do not attain a large size in the perineum, and that urine effused in consequence of rupture of the urethra does not extend backwards to the rectum or outwards to the thigh, but continues forward, and, if an outlet for its escape should not be afforded by the surgeon, reaches successively the scrotum, the

Fig. 507.



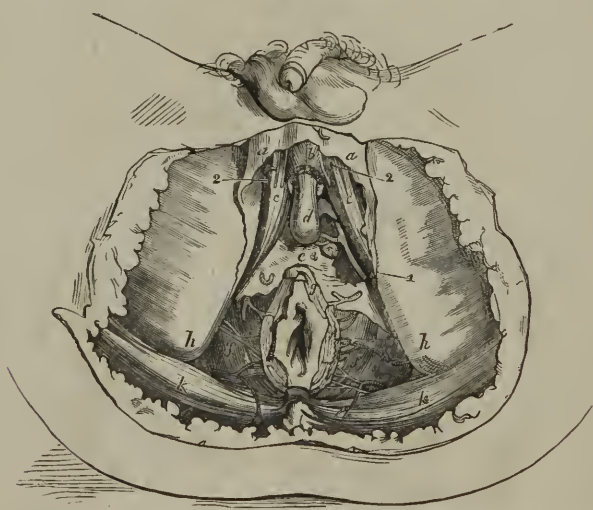
The perineum and part of the thighs after the skin and a portion of the superficial fascia had been removed.—*a.* Superficial fascia. *b.* Accelerator urinæ. *c.* Erector penis. *d.* Transversus perinei. *e.* Upper point of sphincter ani. *f.* The edge of the glutæus maximus.—1. Superficial perineal artery. 2. Superficial perineal nerve.

penis, and the groin above Poupart's ligament. In extreme cases the extravasated fluid would spread from the position last mentioned over the anterior part of the abdomen and even to the thorax, its extension downwards to the thigh being restrained by the attachment of the superficial fascia along the fold of the groin.

The *muscles* brought into view by the removal of the superficial fascia are, on each side, the accelerator urinæ, erector penis, and transversus perinei (fig. 507). Between these muscles is a depression, in which access may be gained to the membranous part of the urethra, without wounding the erectile tissue of the penis, namely, the corpus spongiosum urethræ with its bulbous enlargement on the one hand, and the crus of the corpus cavernosum on the other, covered respectively by the accelerator urinæ and the erector penis. Along this depression is placed the superficial artery of the perineum, with the accompanying nerve, and the transverse artery crosses behind it; at the bottom of the depression, after the muscular structure has been turned a little aside, the deep perineal fascia is met with.

The last-named membrane, *deep perineal fascia* (see page 305), fills the space between the rami of the ischium and pubes, and is therefore necessarily triangular in shape (fig. 509). It consists of two laminæ of fibrous membrane (fig. 510, *b*), the anterior being much the thicker and more tendinous of the two. The layers are separated by an interval, in which the compressor muscles of the urethra (vol. ii. p. 538) are lodged, together with Cowper's glands and the arteries of the bulb, as well as the pudic arteries and nerves for a short space (fig. 508). Where it

Fig. 508.



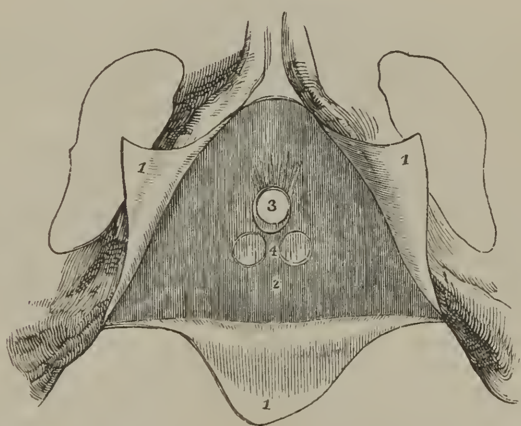
A deeper dissection than that represented in the last figure, the perineal muscles being removed and also the fat in the ischio-rectal fossa.—*a*. Superficial fascia. *b*. Accelerator urinæ. *c*. Crus penis. *d*. The bulb. *e*. Triangular ligament of urethra. *f*. Levator ani. *g*. Sphincter. *h*. Tuberosity of ischium. *k*. Glutæus maximus. * Cowper's gland of the left side. 1. Pudic artery. 2. Superficial perineal artery and nerve. The inferior hemorrhoidal arteries and the artery of the bulb are likewise shown.

is perforated by the membranous portion of the urethra, the fore part of the deep perineal fascia is continuous with the fibrous cover of the bulb and corpus spongiosum urethræ, so that the fascia does not present a defined edge to the tube which passes through it. The posterior layer is connected with the capsule of the prostate gland.

The *anterior* of the two *layers* here and elsewhere in this work (vol. i. p. 305) noticed as constituting the deep perineal fascia, is that which alone forms the *triangular ligament of the urethra.* (See especially Camper, Demonstrationes Anatomico-Pathologicæ.) It is that layer which, being pierced by the urethra, interferes with the passage of instruments along the canal. Moreover, it is the only part of the structure recognised by most anatomical writers. The slip of membrane described as the *posterior layer* of the deep fascia, in accordance with the plan which appears to be now generally received in this country (Colles' "Surgical Anatomy," p. 191; Harrison, "Dublin Dissector," vol. i. p. 315; Guthrie "On the Neck of the Bladder," &c., p. 41), might be regarded as a dependency of the membranes lining the pelvis.

The structure next met with in examining the perineum, is the levator ani (its fore part) figs. 509, 511, and immediately under that muscle

[Fig. 509.



The pubic arch with the attachment of the perineal fasciæ. 1, 1, 1. The superficial perineal fascia divided by a ʌ shaped incision into three flaps; the lateral flaps are turned over the ramus of the os pubis and ischium at each side, to which they are firmly attached; the posterior flap is continuous with the deep perineal fascia. 2. The deep perineal fascia. 3. The opening for the passage of the membranous portion of the urethra, previously to entering the bulb. 4. Two projections of the anterior layer of the deep perineal fascia, corresponding with the position of Cowper's glands.—W.]

is the prostate. Placed before the neck of the bladder, around the urethra, behind and below the arch of the pubes, and above the rectum, the prostate is supported by the levator ani and the pelvic fascia,—the latter dropping down from the pubes on its base. It is invested with a fibrous covering, and on this account the outer surface does not readily yield to a cutting instrument, while the proper substance of the gland is cut or lacerated with comparative facility. From the increase of its breadth towards the lower surface, it follows that the greatest

extent of incision from the urethra, without wholly dividing the gland, would be made in a direction outwards and backwards.

Fig. 510.

The pelvic viscera of the male seen on the left side.—1. The body of the left pubes sawed through. 2. Corpus cavernosum penis. 2'. Corpus spongiosum. 3. Prostate gland, with a portion of the levator ani covering its fore part. 4. Urinary bladder. 5. Intestinum rectum. 6. Deep perineal fascia—its two layers. 7. Cut edge of the pelvic fascia extending from the pubes to the back part of the prostate. 8. Vas deferens. 8'. Vesicula seminalis. 9. Ureter. The cut edge of the peritoneum is seen jagged over the bladder and the rectum.

The examination of the prostate by the surgeon is made through the rectum. It is only through the gut that it can be felt. When the gland is enlarged, as it commonly is in aged persons, the urethra is raised above its natural level and elongated. But the augmentation of size may be partial, affecting one lateral lobe (a rare occurrence) and then the urethra is inclined to one side; or the middle and posterior part or middle lobe may be projected upwards at the orifice of the urethra, so as even to obstruct the escape of the urine from the bladder. In this last case, the point of the instrument passed along the urethra, must be inclined upwards more than is required in the healthy condition of the parts, in order that it may be made to enter the bladder over the projection referred to. The part of the urethra encircled by the prostate admits of considerable dilatation. For the position of the seminal and other openings into it, reference may be made to the description of the canal at page 534, vol. ii.

Behind the prostate the neck of the urinary bladder presents itself. Here the bladder is bound to the pubes at its upper part by the pelvic fascia, the bands of which are named its anterior and lateral ligaments. Laterally the fascia reaches the organ in question over the base of the prostate, (fig. 511); and an elongation from the same membrane extends from side to side between the bladder and the rectum after investing the vesiculæ seminales and vasa deferentia.

Turning attention in the next place to the *rectum*, which occupies the irregularly-shaped space behind the perineum, we shall recall a few particulars respecting it. The lowest or third division of the bowel, which measures about an inch and a half in length, is directed obliquely backwards from the fore part of the prostate to the anus (fig.

511); and as at the same time the urethra here inclines forwards with the penis, the space between the two widens towards the surface of the peritoneum. Into this space the bulb of the corpus spongiosum drops down occupying it more or less according as the erectile tissue is more or less distended. The part of the rectum now under consideration narrows to its end under the influence of the sphincters. It is supported by the levatores ani, which are fixed to its sides, and by the pelvic fascia on the inner surface of those muscles.

From this its shortest and narrowest part, the intestine sweeps into the hollow of the sacrum, widening considerably at the same time so as to form a large pouch (fig. 511). This part, which is known as the second division of the rectum, has before it the prostate and the urinary bladder with the seminal vesicles, and above these the recto-vesical pouch of the peritoneum. The rectum and the bladder are in contact one with the other, only in the small triangular space intercepted between the seminal vesicles and the peritoneum (fig. 512); and

Fig. 511.

Besides the superficial fascia and the perineal muscles, by the removal of which the spongy erectile tissue and the crura penis were uncovered, the anterior layer of the deep perineal fascia was cut away in the preparation for this sketch, and thus the pudic arteries, with their branches for the bulb, and Cowper's glands have been laid bare. The rectum too having been dissected from its connexions and drawn back, the prostate gland, the seminal vesicles, and part of the urinary bladder have been brought into view.—1. Fascia lata covering the adductor muscles of the thigh. 2. Glutæus maximus. 3. Rectum. 4 Crus penis of left side. 5. Corpus spongiosum urethræ. 6. Prostate. 7. Vesicula seminalis and vas deferens of left side. 8. A small part of urinary bladder. 9. Right dorsal artery, with the artery of the bulb and Cowper's gland resting against the inner layer of the deep perineal fascia. The last-named parts are at considerable depth, but the size within which it was necessary to restrict the drawing, did not admit of the appearance of depth being sufficiently preserved in this representation.

in this space the bladder may be punctured, in order to evacuate its contents. In performing the operation, the chief guide to the surgeon is the prostate. The instrument is to be passed forward into the bladder behind this gland; but care must be taken to regulate the distance from its margin, so as to avoid wounding on the one hand the vasa deferentia which come into apposition one with the other immediately behind it; and, on the other hand, the peritoneum where this membrane turns from one of the organs to the other. At the same

time it is to be remembered, that by the inclination of the trocar to either side, the seminal vesicles would be endangered. The part of the intestine now under observation rests against the conjoined levatores ani, the coccyx, and the sacrum.

The lower end of the rectum receives small arteries on each side from the pudic (fig. 508); but its principal artery (the superior hæmorrhoidal, the continuation of the inferior mesenteric) is placed behind the organ and gives branches to each side. The larger branches do not extend within reach of a forefinger of ordinary length. The veins, like those of the abdomen generally, are without valves. These vessels are very liable to enlarge and become varicose; and this condition is constantly associated with, or even forms, a great part of the disease known as hæmorrhoids.

Ischio-rectal fossa.—On each side of the rectum between it and the ischium is contained a considerable quantity of fat, the space which it occupies being named the ischio-rectal fossa. This hollow extends backwards from the perineum to the great glutæal muscle, and is bounded on the inner side by the levator ani as this muscle descends to support the intestine, on the opposite side by the obturator fascia and muscle supported by the ischium. At the outer side and encased in a sheath of the obturator fascia is the pudic artery with the accompanying veins and nerve; and small offsets from these cross the fossa to supply the lower end of the rectum. The pudic artery, it will be observed, is about an inch above the lower surface of the tuber ischii, and at the same time, by its position under that prominence of the bone, it is protected from injury by incisions directed backwards from the perineum; but in front of this part, in the perineum, inasmuch as the vessel lies along the inner margin of the branches of the ischium and pubes, it is here liable to be wounded when the deeper structures of the perineum are incised.

The fossa is narrowed as it reaches upwards into the pelvis; such narrowing of the space is the necessary result of the direction of the levator ani, which drops inwards from the fascia on the side of the pelvis, and thus limits the fossa at its upper end.

LATERAL OPERATION OF LITHOTOMY.

The intention of the operation, as it is usually performed, is to remove a calculus from the urinary bladder by an opening made through the perineum and the prostatic part of the urethra. The incisions to attain this end are commonly made on the left half of the perineum, because this side is most convenient to the right hand of the operator; but, if the surgeon should operate with the left hand, then the opposite (right) side of the perineum would be most convenient.

The position at which the perineum is to be incised requires careful consideration. For if the necessary incisions should be made too near the middle line of the body, the bulbous enlargement of the corpus spongiosum urethræ and the rectum are liable to be wounded; and if, on the other hand, the perineum should be divided towards its outer boundary (the conjoined branches of the pubes and ischium), there is a risk of wounding the pudic artery where that vessel has reached the

inner edge of the bone. The incisions are therefore to be made through the area of the small perineal space in such manner as to avoid both its sides. Again, as to the length to which the several structures are to be incised:—The integument and the subcutaneous cellular membrane must be divided with freedom, because, 1st, the skin does not admit of dilatation during the removal of the foreign body; and 2dly, extensive incisions through the structures near the surface facilitate the egress of urine, which, after the operation, continues for a time to trickle from the bladder. But the prostate and the neck of the bladder, on the contrary, are to be incised in but a small extent. The reasons for this rule may be stated as follows:—By accumulated experience in operations on the living body, it has been found that the structures now under consideration when slightly cut into admit of dilatation, so as to allow the passage of a stone of considerable size, and that no unfavourable consequence follows from the dilatation. Moreover, when these parts are freely divided (cut through), the results of lithotomy are less favourable than in the opposite circumstances. The less favourable results adverted to appear to be due to the greater tendency to infiltration of urine in the cellular membrane of the pelvis; and the occurrence of this calamity probably depends on the fact that when the prostate has been fully cut through, the bladder is at the same time divided beyond the base of the gland, and the urine then is liable to escape behind the pelvic fascia (which it will be remembered is connected with both those organs at their place of junction); whereas if the base of the gland should be left entire the bladder beyond it is likewise uninjured, and the urine passes forward through the external wound.

The steps of the operation by which the foregoing general rules are sought to be carried out are the following:—The grooved staff having been passed into the bladder (and this instrument ought to be of as large size as the urethra will admit), and the body or the patient, as the case may be, having been placed in the usual position—by which position the perineum is brought fully before the operator with the skin stretched out—the first incision is begun about two inches before the anus, a little to the left of the raphé of the skin, and from this point it is carried obliquely backwards in a line about midway between the tuber ischii and the anus, extending a little way behind the level of the latter. During the incision, the knife is held with its point to the surface, and it is made to pass through some of the subcutaneous cellular membrane as well as the skin. Now, the edge of the knife is applied to the bottom of the wound already formed, in order to extend it somewhat more deeply; and the forefinger of the left hand is passed firmly along for the purpose of separating the parts still further, and pressing the rectum inwards and backwards out of the way. Next, with the same finger passed deeply into the wound from its middle and directed upwards, the position of the staff is ascertained and the structures still covering that instrument are divided with slight touches of the knife,—the finger pressing the while against the point at which the rectum is presumed to be. When the knife has been inserted into the groove of the staff (and it reaches that instrument in the membra-

nous part of the urethra) it is pushed onwards through the prostatic portion of the canal with the edge turned to the side of the prostate, outwards, or, better, outwards with an inclination backwards. The knife being now withdrawn, the forefinger of the left hand is passed along the staff into the bladder. With the finger the parts are dilated, and with it, after the staff has been withdrawn, the position of the stone is determined and the forceps is guided into the bladder.

In case the calculus is known to be of more than a moderate size and the knife used is narrow, the opening through the side of the prostate may be enlarged as the knife is withdrawn, or the same end may be attained by increasing the angle which that instrument, while it is being passed onwards, makes with the outer part of the staff. And if the stone should be of large size, it will be best to notch the opposite side of the prostate likewise before the forceps is introduced. The same measure may be resorted to afterwards should much resistance be experienced when the foreign body is being extracted. Lastly, this part of the operation (the extraction of the stone) should be conducted slowly, so as gradually to dilate the parts without lacerating them; and the forceps should be held with its blades one above the other.

The Structures divided in the Operation.—In the first incision the integument and the subjacent cellular membrane are divided; afterwards a small part of the accelerator urinæ, and the transversus perinæi with the transverse artery. Then the deep perineal fascia with the muscular fibres between its layers, the membranous part of the urethra, the prostatic part of the canal, and, to a small extent, the prostate itself, are successively incised.

The blood-vessels: their relation to the incisions.—The transverse artery of the perineum, with, it may be, the superficial artery of the perineum, is the only artery necessarily cut through when the vessels have their accustomed arrangement; for in such circumstances the artery of the bulb is not endangered if the knife be passed into the staff in a direction obliquely upwards, the artery being anterior to the groove of that instrument; neither is there a risk of wounding the pudic artery, unless the incisions through the deep parts (the prostate for instance) should be carried too far outwards.*

But in some cases the arteries undergo certain deviations from their accustomed arrangement, whereby they are rendered liable to be wounded in the operation. Thus, the artery of the bulb when it arises, as occasionally happens, from the pudic near the tuber ischii, crosses the line of incision made in the operation.† The arterial branches ramifying on the prostate are in some instances enlarged, and become a source of hemorrhage;‡ and the veins too on the surface of that

* For reference to some cases in which the pudic artery was divided in lithotomy, see Mr. Crosse's "Treatise on Urinary Calculus," p. 21. London, 1835.

† "The Anatomy of the Arteries," &c., by R. Quain, p. 442, and plate 64, figs. 1 and 2. A case in which death resulted from division of the artery of the bulb is recorded by Dr. Kerr, in the "Edinb. Med. and Surg. Journal," July, 1847, p. 155.

‡ See an essay, entitled "Remarks on the Sources of Hemorrhage after Lithotomy," by James Spense, in the "Edinburgh Monthly Journal of Medical Science," vol. i. p. 166; 1841. And "The Arteries, &c., by R. Quain," p. 445.

gland, when augmented in size, may give rise to troublesome bleeding.* Lastly, it should be added that the occasional artery (accessory pudic) which takes the place of the pudic when defective, inasmuch as it lies on the posterior edge of the prostate, would be divided if the gland were cut through to its base, and only in this event.†

* "The Arteries, &c., by R. Quain," p. 446, and plate 65, fig. 3.

† Ibid. p. 444, and plate 63. An instance in which fatal consequences resulted from the division of such an artery has been placed on record. See "Case of Lithotomy attended with Hemorrhage, by J. Shaw, Esq.," in "The London Medical and Physical Journal," vol. lv. p. 3, with a figure. 1826.

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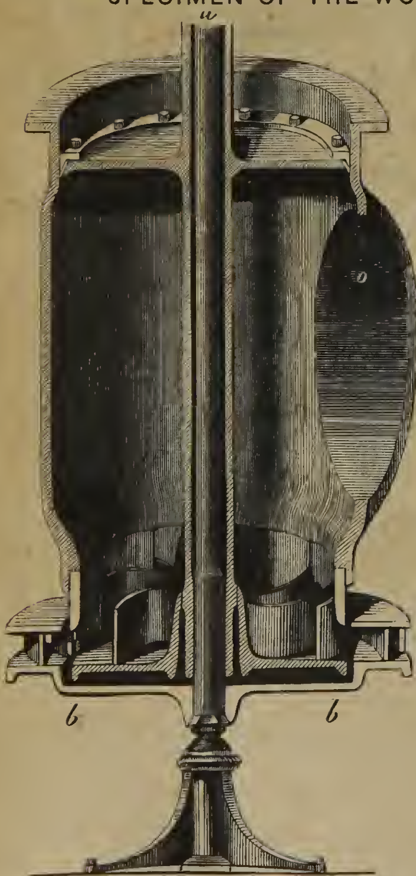

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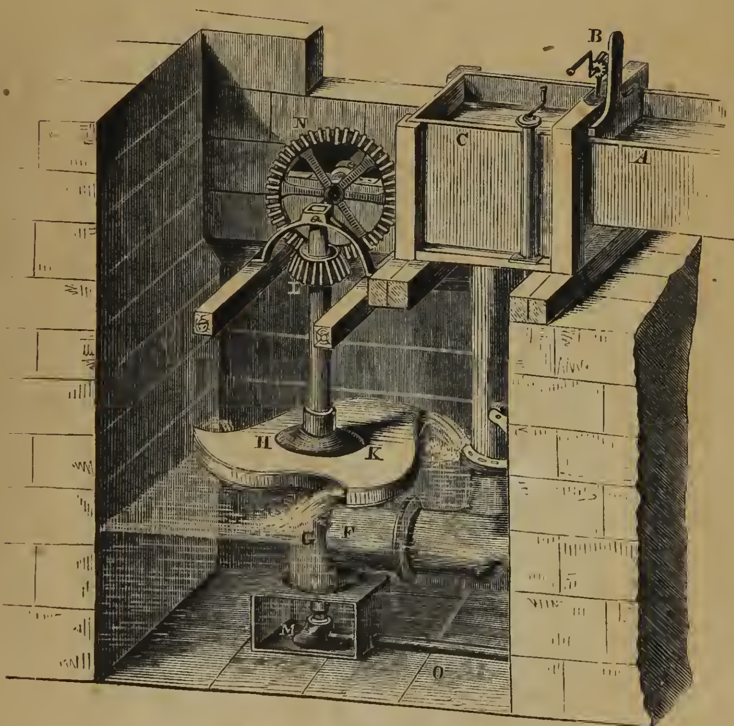

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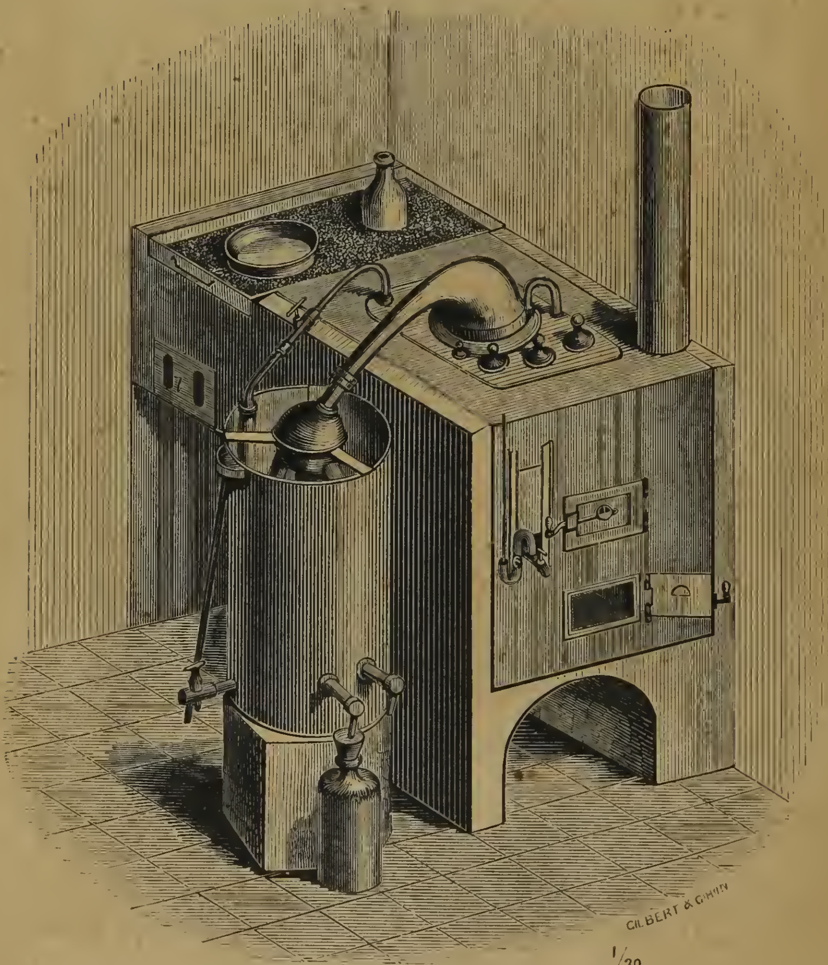

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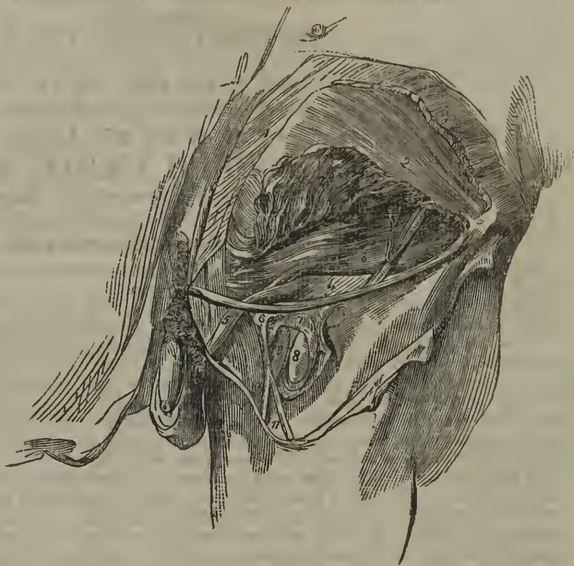

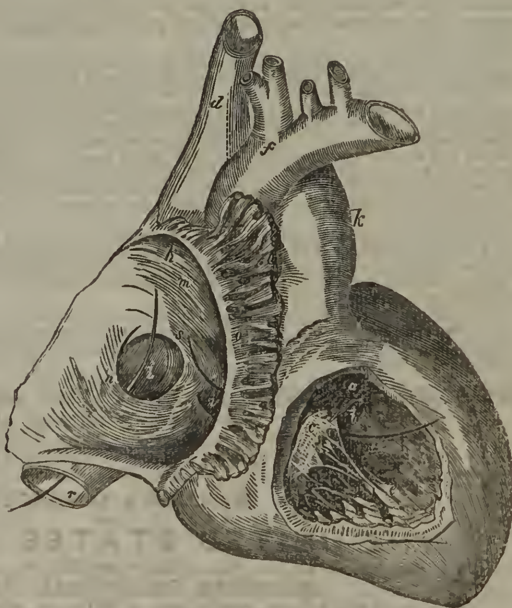

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